THE TELEGRAPHIC JOURNAL AND

ELECTRICAL REVIEW.

VOL. XXVI. APRIL 11, 1890. No. 646.

CONTENTS:

	PAGE
Electromotive Force and Insulation Resistance	393
Theory of Accumulators	394
Lieut. Fiske's Position-Finder (*illustrated*)	396
The MacMahon Electric Check System	397
Underground Lines	398
The Fiske Range-Finder (*illustrated*)	399
Lightning Conductors (*illustrated*) (*concluded*)...	400
Queen's New Triple-Plate Toepler-Holtz Machine (*illus.*)	403
The Falls of the Clyde as a Source of Power	404
Electrical Calculations	404
The Temperature Coefficient of Swan Lamps	406
Notes...	407
City Notes, &c. :—	
Brighton Electric Light Company	411
City Notes, &c.—(*continued*)—	
Bedford Electric Light Company	411
Exeter Electric Light Company	411
Traffic Receipts	412
Share List of Electrical Companies	412
Electric Railroads	413
Physical Fields	413
Electric Lighting and Town Authorities	417
New Patents	418
Abstracts of Published Specifications	418
Correspondence :—Dynamo and Motor Design	418
Workmen's Grievance	419
More Light on Electricity	419
The Physiological Effects of Currents	419
Far-Distance Dynamo (*illustrated*)	420
Alternating Current Motors	420

ELECTROMOTIVE FORCE AND INSULATION RESISTANCE.

OUR attention has been called to a series of articles which appeared some time since in our contemporary *L'Electricien*, and in which M. Lafargue recapitulates the results of certain experiments carried out by M. Förderreuther. The last-named gentleman has arrived at the conclusion that the insulation resistance of a cable varies according to the potential of the current applied. M. Lafargue would appear to lend some credence to this opinion, and a contributor to the columns of the *Lumière Electrique* also seems to share this belief.

It is scarcely worth while to controvert such a theory, but the support given to the proposition by the publications above mentioned may serve as a reason for referring to the matter in our columns; at the same time we would disclaim any intention of affronting the intelligence of our readers by bringing before their notice a subject which, except for the reason above given, would appear unworthy of serious consideration.

To prove his contention, M. Förderreuther gives a table of voltages and their corresponding resistances, showing the following variations :—

Volts	=	7·4	14·8	22·1	29·4	36·7	44·4	51·6	
Insulation resistance, megohms.	=	11,030	8,180	7,700	7,370	7,160	7,040	6,860	(*a*)
Volts	=	51·6	44·8	36·7	29·4	22·1	14·8	7·4	
Insulation resistance, megohms.	=	6,840	7,040	7,160	7,370	7,700	8,180	10,500	(*b*)

It is to be remarked that throughout these experiments the intermediate results, when increasing the voltage (Test "*a*"), correspond almost exactly with the values obtained at similar voltages when decreasing the E.M.F. (Test "*b*").

It is also worthy of notice, that although the insulation in Test "*a*" is reduced to nearly one-half, yet Test "*b*" would indicate that no permanent damage to the insulation seems to have been caused.

M. Lafargue remarks that there is nothing to be apprehended from the results of this experiment, since the differences obtained in the two tests might easily be due to errors of observation. Yet, although the whole theory is condemned by such a possibility, M. Lafargue claims for the question a certain importance, and actually appears to have come to the conclusion that there is an undoubted fall of insulation due to increase of voltage. Apart from the question of error, such a notable loss as that of nearly one-half the insulation by increasing the E.M.F., from 7·4 to 51·6 volts, is, in any case, a matter of very serious import, more especially since it is attempted, from the results given, to establish the maxim that insulation must naturally diminish as the E.M.F. is increased. Supposing that M. Förderreuther had increased the E.M.F. in his experiments to 100 volts, a very usual voltage on electric light circuits, we should then, according to his showing, meet with a most formidable loss of insulation.

A more reasonable conclusion to arrive at from M. Förderreuther's results would be that a weak point existed in the cable under test, the insulation being considerably more affected by the higher than by the lower voltage. It does not at all follow that because a weak point exists it should immediately develop into an absolute fault, more especially if the cables have been tested under conditions of current, weather, position, &c., least likely to affect a weak place; under such favourable circumstances M. Förderreuther might easily obtain the results he quotes when reversing the order of voltages as shown in Test "*b*." But on the other hand the remarkable regularity shown in the results, would lead one to doubt more the method of testing than the condition of the cable.

To further support the argument more elaborate experiments are quoted. A sketch is given purporting to show the system pursued in testing, the formula used for working out the results of tests is explained, and a table is made out in which are shown the voltages employed, the deflections observed and the insulation resistances obtained in the course of tests made on several cables. The results given in this table are

similar to those already quoted, the insulation in every case decreasing as the electromotive force is increased. The cables are tested in pairs, the insulation of each is given separately, and then that of the same cables joined up so as to measure their combined insulations when in series. This last result should of course be equal, within reasonable limits, to the sum of the two measured separately, but in no instance is this the case, the resistance through the double thickness of insulation offered by the two cables when tested in series being very much less than that through either one.

The formula is no doubt correct, but on comparing the results given in the table, we find some difficulty in reconciling them. In fact, the only approximately satisfactory results are those obtained on cables where there was next to no insulation ; on this basis we might argue that if there were no insulation at all the results would have been absolutely comparable.

M. Lafargue in commenting on these tests and the tabulated results, notices the absence of accordance between them, but instead of attributing the discordance to the proper cause, he apparently accepts the figures and arrives at the remarkable conclusion that no law can be given for connecting the values of the same cables when tested separately and then together.

We are inclined to think that some mistake has been made with regard to the deflections, either in observing or in calculating their values, for by adopting them as given in the table and following the formula, we obtain, in trying to arrive at the galvanometer resistance, a minus quantity. It is evident that a very small error in the deflections would materially alter the result of the calculations of galvanometer resistance.

From these tests a table is made out of the deflections which should correspond to various voltages, given the deflection obtained with a certain E.M.F., and a formula, based on a constant obtained from the tests, is constructed for calculating these deflections. Since the results of the tests would show that insulation diminishes as voltage is increased, any formula based on such an utterly incorrect hypothesis must be valueless. Of course the voltage can be increased to such an abnormally high point that the insulating material will no longer resist the strain brought to bear upon it, but so long as the cable remains sound there will certainly not be the gradually decreasing insulation which M. Förderreuther attempts to show.

It so happens that we have been able to place our hands on certain tests, made for experimental purposes on some gutta-percha and India-rubber core. The results point to nothing unexpected, nothing new, but are certainly opportune in that they may prove of some value to M. Förderreuther and the adherents to his theory, who may perhaps accept the evidence of accurately effected experiments.

The core was tested in water maintained at a temperature of 75° Fahr.

5·0 NAUTICAL MILES OF GUTTA PERCHA CORE.

Temperature 75° Fahr.

Volts ... ... =	15	60	150	300	600
Insulation resistance per N.M., megohms =	1,016	1,027	979	1,048	1,083

3·0 NAUTICAL MILES OF INDIA RUBBER CORE.

Temperature 75° Fahr.

Volts ... ... =	60	150	300	600
Insulation resistance per N.M., megohms =	3,120	2,966	2,974	3,105

We would point out to M. Förderreuther that such irregularities as are observable in the above results are simply due to unmeasurable variations in temperature and errors of observation.

THEORY OF ACCUMULATORS.

IN a paper recently read before the Chicago Electric Club, Dr. P. Schoop advanced a new explanation of the sulphate theory, and he endeavoured to show, among other things, that the variation in the density of the electrolyte is not due, as commonly accepted, to the successive formation and removal of sulphate during the discharge and charge of a lead sulphuric acid cell, but to the combination of hydrogen and oxygen in the one case and the decomposition of water in the other. Dr. Schoop's theory is that "the charged cathode of a lead accumulator contains an alloy of lead and hydrogen, and this hydrogen-alloy is the true active material. The anode contains oxygen, not in a condensed state or as an alloy, and not firmly united, in a chemical compound, namely, that dark, most highly oxydised peroxyde of lead. As soon as the discharge commences the cathode loses hydrogen, and the black compound on the anode loses oxygen ; these gases are combined and form water, which again is dissolved in the sulphuric acid. For each pound of water formed in this manner about 700 ampère-hours are delivered. At the end of the discharge we have then the cathode, containing lead nearly free from hydrogen and the anode, a chocolate brown compound, containing less oxygen than the black compound, and the electrolytic fluid containing a pound more water than before. The specific gravity, of course, must have fallen, because pure water has been added to it by the discharge. After charging, the cathode again contains the saturated hydrogen alloy, the anode, the black compound, and the dilute acid less water than at the beginning of the charging, because a certain quantity of pure water was decomposed and removed. The specific gravity must have increased. The addition of about one-fifth of a pound of water to 27 pounds of dilute acid of 1,220 specific gravity will give us the same specific gravity as the removal of one pound of concentrated sulphuric acid." In the *Western Electrician* Prof. H. S. Carhart takes up the cudgels, and endeavours to show Dr. Schoop the error of his ways. Writing on the change of density of the electrolyte, Prof. Carhart says, "No statement could be wider of the mark. Let us see how much water must be added to 27 lbs. of dilute acid of density 1,220, containing about 8 lbs. of acid to reduce the density to 1,175, or so that the acid will constitute 24 per cent. of the whole mass. The simple question is, 8 is 24 per cent. of how many pounds? The answer is 33·3. Hence, 6·3 lbs. of

water must be added to the 27 pounds in order to effect the reduction of density from 1,220 to 1,175. This is in accordance with the tables, and I have verified it by experiment. It amounts to 23·3 per cent. by weight, or an addition of 28·4 per cent. by volume. Now, in the first place, no appreciable change in the volume of the liquid in the cell has ever been noted; certainly no such preposterous change as 28 per cent. ever takes place. But if the change in density is to be accounted for by the addition of water formed in the reaction accompanying the discharge, then there is no way to avoid the above conclusion."

Considering the energy involved in this transaction, Prof. Carhart further states, "One ninth of the weight of water added is hydrogen, equal to seven-tenths of a pound, or 317 grammes. The heat combination of one gm. of hydrogen with oxygen is 34,000 gm. degrees, or $1{\cdot}43 \times 10^{12}$ ergs. Hence the 317 gms. of hydrogen by union with oxygen will produce $317 \times 1{\cdot}43 \times 10^{12} = 453{\cdot}31 \times 10^{12}$ ergs of energy. Two ampère-volts for one hour equal $2 \times 3{,}600 \times 10^{7} = 72 \times 10^{9}$ ergs. If, therefore, the storage is due to occluded oxygen and hydrogen, then such a cell, containing 27 pounds of liquid, should have a capacity of about 7,000 ampère hours. The actual capacity is only one thirty-fifth of this. Or again, the electro chemical equivalent of hydrogen is 0·00001035 gms. per coulomb. Hence to produce 317 gms. of hydrogen from water would require $317 \div 0{\cdot}00001035 = 30{,}628{,}000$ coulombs of electricity. Hence 8,500 ampère hours of charging would be required to produce the 317 gms., or seven-tenths of a pound of hydrogen from 6·3 pounds of water, which, by its withdrawal from the liquid would raise the density from 1,175 to 1,220. The volume of this gas under standard conditions would be 3,538 litres, or 778 gallons. This would come from three-fifths of a gallon of water, which would have to disappear and reappear in every 200 ampère hour cell with each charge and discharge." Is it not apparent, asks Prof. Carhart, that Dr. Schoop's theory does not hold (enough) water?

Look on This Picture and on That.

A CORRESPONDENT writes as follows: "In view of Mr. de Ferranti's report on the failure of the cables from the Deptford central station, it is interesting to see what were the opinions expressed some time ago on the subject. In turning over some old papers I have just come across, a notification slip issued by the Society of Engineers, stating that the Society paid a visit to the Deptford works on October 1st, and referring the reader to a "short description annexed." There is nothing to show who is responsible for the description in question, whether it is a reprint from a newspaper, the opinion of Mr. de Ferranti, or the views of the Society of Engineers. I do not think it could have emanated from Mr. de Ferranti as it is stated that this gentleman has a fertile brain and is a young genius. The following passage is, however, the one to which I desire to draw attention. 'A question has been frequently asked how the electric current, when generated at Deptford, is to be conveyed to the various parts of the metropolis. This question by no means embarrasses the promoters of this great undertaking, for in truth the answer is very simple. Current has been conveyed a distance far in excess of the distance in question on the system adopted by the London Electric Supply Corporation, and that at a time when the system had not reached the stage of perfection to which it has now attained. The current is what is known as alternating and is generated at high tension, and the mains used by this Corporation, which are of quite novel construction, not only convey the current to a great distance without material loss, but what is even of more importance, do so with absolute safety, as has been clearly shown by a long and exhaustive series of experiments, undertaken with the express view of satisfying the several railway companies over whose systems the current will (by agreement already entered into) be conveyed.' This again proves the wisdom of Josh Billing's axiom that it is unwise to prophecy unless one knows."

Tinned Copper Wire.

THE remarks made by our correspondent, Mr. F. W. Cooke, in our last issue, are interesting as indicating faults of a kind occurring in tinned copper wire other than the peculiar class we alluded to in our article of the 28th ult. The *brittleness* of some samples of wire will almost invariably be found in the plain wire before it has been tinned, the process of tinning not usually having such an effect. Overheating would tend to soften the wire, and not to harden it. Soft and hard places in the same coil are not infrequently met with in all sizes of wires and coils, but they must be set down as entirely due to faulty manufacture previous to tinning, and they are naturally a source of great trouble, whether plain or tinned wire be used. As to the penetration of the tin into the copper, to which our correspondent alludes, we have not noticed such an effect in a *broken* wire; but if the wire be *cut* with a pair of plyers, this effect will be seen, although the tin be superficial only, the cutting carrying a portion of the tin with it. If the wire be scraped with a knife it will be seen that the tin is only on the surface. The extra diameter given by the tin coating to a wire is infinitesimal, and is, as stated, superficial.

Execution by Electricity.

AS announced in our last, the appeal case of the man Kemmler has been decided against him, and the first execution by electricity is to take place in the week commencing April 28th next. The following particulars are to hand relative to this appeal. The opinion of the Court of Appeal was unanimous; the decision recites the appointment of the Commission to investigate a humane method of death punishment and the enactment of the electric statute, and says:—"The decision of the Legislature is conclusive upon the courts. The amendment to the code making the new penalty is not in general purposes or intent a violation of any provision in the Constitution." The testimony taken by the referee, while not impeaching the validity of the Legislature's acts, is a valuable collection of opinions, but nothing more. The Court finds that the mode proposed is not cruel within the meaning of the Constitution, though unusual. On the contrary, all agree with the Court below that it removes every reasonable doubt that the application of electricity to the vital parts of the human body under such conditions and in the manner contemplated by the statute must result in instantaneous and consequently painless death.

LIEUTENANT FISKE'S POSITION-INDICATOR.*

IN our issue of February 8th † we described Lieut. Bradley A. Fiske's invention for finding the distance of far away objects. We shall now proceed to describe an invention by the same officer, whereby not only is the distance and exact position of a far away object determined, but whereby also any number of guns located at different points and at various distances from that object and from the instrument may be directed upon the object with certainty and dispatch, though enveloped in the impenetrable smoke of battle.

The invention has a special reference to forts containing a number of guns variously disposed. That a mere distance-finder does not meet the necessities of a fort will be evident from a glance at fig. 2, from which it will be seen that the gunners at C, D and E are benefitted little by knowing how far away the enemy's ship is from the instruments at K and L. The men at each gun must know how far the target is from that gun, and in what direction; evidently the knowledge of the direction and distance of the target from C will help the gunners at E very little.

The present practice in most of the nations of the world is to divide a harbour and adjacent waters into imaginary squares, each square being, say, 100 yards on a side, and these squares are numbered. Two telescopes are situated at the ends of a known base line, and these telescopes are electrically connected with a protected room, in which is placed a chart representing the fort and the adjacent waters, and carrying two long pointers arranged to sweep over the chart, and pivoted at the points representing the two telescopes. The men at the telescopes direct them continually at the target, and keep the officer at the chart constantly advised as to how their telescopes are pointing. The officers at the chart then point the pointers in the same direction as the telescopes are pointed, and therefore the intersection of the pointers on the chart represents the intersection of the lines of sight of the telescopes, that is, represents the target. The officer then notes the number of the square on which the pointers intersect, and signals to the guns this number. The officer in charge of each gun then consults a table to ascertain how he must lay his gun to fire into that square, and trains and elevates his gun accordingly.

This plan is a fairly good one if the enemy is stationary; but if he is moving it has a number of defects; although even if he is stationary, the squares, of necessity, are too large to admit of very accurate shooting. If the enemy is moving the additional difficulties of the above plan arise from the great time lost between the instant at which the position becomes known to the officers at the chart and the instant at which the gun is finally elevated and trained. Another is, the number of different errors that may arise; these are, first, the error in noting the square at which the pointers intersect; second, the error in signalling the square; third, the error in reading the signal; fourth, the error in consulting the necessary tables; fifth, the error in transmitting the instructions to the men as to how to train and elevate; and sixth, the error, in laying the gun according to those instructions, both in azimuth and altitude. To avoid any inaccuracy owing to the time that is lost, Major Watkin, by his method, predicts the position in which the enemy will be, say in half a minute, or a minute in advance, and the guns are got ready to fire when the signal is made that the predicted position has been reached by the enemy's ship. Now this feature of predicting entails several chances of error, necessitates a speed-measuring device, and also necessitates a preconcerted division of the harbour into squares, or otherwise, so that position points can be readily designated.

By the plan here described all these sources of error and delay are avoided, and the men at each gun receive continuously, instantaneously and automatically, a signal of what is to be done, given in a way that entails no noise, and which cannot possibly be misunderstood.

The value of the device comes into especial prominence if we remember that it is absolutely necessary to locate and indicate the position, not only of one, but of several ships. A position indicator should be attached to each group of guns; then these different groups can be concentrated on one ship, or made to fire at different ships according to the judgment of the commanding officer.

Referring to fig. 2, A, B represent a line of the parapet of a fort or other defensive work. C, D and E are guns located in the fort and commanding the area which includes the position of the target F. The object to be attained is to lay all of the guns, C, D, E, correctly upon the target, although the persons in charge of the guns may be unable to see the target and be ignorant of its bearing and distance. For purposes of clearness, in the following description we shall refer only to the necessary operations connected with one gun, as E, premising that the same method is followed in connection with every other gun.

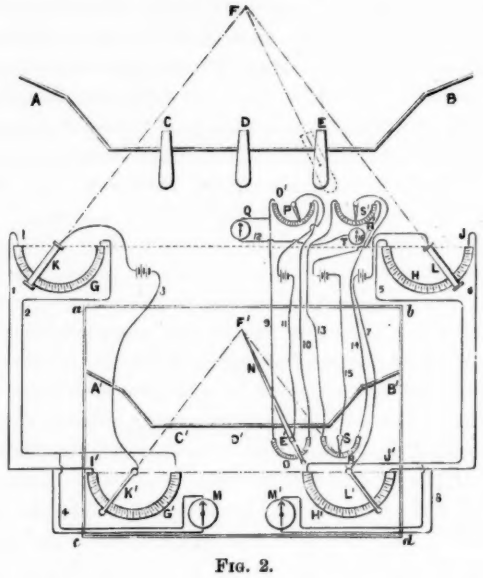


FIG. 2.

G and H are two arcs of conducting material placed symmetrically with respect to a base-line, I, J. These arcs are located at stations distant from the positions of the guns, and so situated that a view of the area to be protected by the guns will not be cut off from the stations by smoke, points of lands or other obstacles. For this reason it is better that elevated positions should be chosen for the stations.

K and L are two pivoted telescopes, the free ends of which move over the arcs, G and H, and constantly maintain electrical contact therewith. These telescopes may be directed upon the target, F, which will, therefore, be at the intersection of the two lines of sight of the telescopes.

Located at a station distant both from the guns and from the positions of the arcs, G, H, and usually at a place safe from the effects of the enemy's fire, there is established another station, which, for convenience, we will call a "directing station," in which is a chart or map, represented by the rectangle, *a*, *b*, *c*, *d*. On this chart the line, A', B', represents the line, A, B, of the parapet of the fort, and the points, C', D', E', correspond to the centres above which the guns, C, D, E, are laterally turned. The chart, *a*, *b*, *c*, *d*, represents the area within the range of the guns, C, D, E, on some definite reduced scale, so that distances taken on the chart represent actual distances. On this chart is drawn a line, I', J', corresponding to the base line, I, J, and symmetrically disposed with reference to that base line are arcs of conducting material, G', H'.

K' and L' are pivoted arms similar to the arms, K, L, the free ends of which pass over and make constant

* *Electrical World.* † See ELECTRICAL REVIEW for February 21st.

contact with the arcs, G′ and H′. Arc G′ is similar in form and in electrical resistance per unit length to the arc G, and the arc H′ is likewise similar in the same particular to the arc H. Extending from the extremities of the arc G to the extremities of the arc G′ are wires 1 and 2, and extending from the pivoted telescope K to the pivoted arm K′ is a wire 3, which includes a battery. Connected in loop from the wires 1 and 2 by a wire 4 is a galvanometer, M. It will be evident that the wires 1, 2, 3, 4, the arcs, G, G′, the battery and the galvanometer, M, are connected in circuit in the form of a Wheatstone bridge, and that the effect of moving the telescope, K, for example, to the right on arc, G, is to increase the resistance in the member 1 of the bridge and decrease it in the member 2, and that the same is true of a similar movement of the arm, K′, over the arc, G′. Therefore if the telescope, K, be set at a certain position on the arc, G, it is simply necessary to set the arm, K′, to such a position on the arc, G′, as that the galvanometer, M, shall show no deflection, when the bridge will, of course, balance, and therefore the angle made by the arm, K′, to the base line, I′, J′, will be equal to the angle made by the telescope, K, to the base line, I, J. The extremities of the arc, H, are connected to the extremities of the arc H′, by wires 5 and 6, and the pivots of the telescope, L, and arm, L′, are connected by wire 7, which includes a battery.

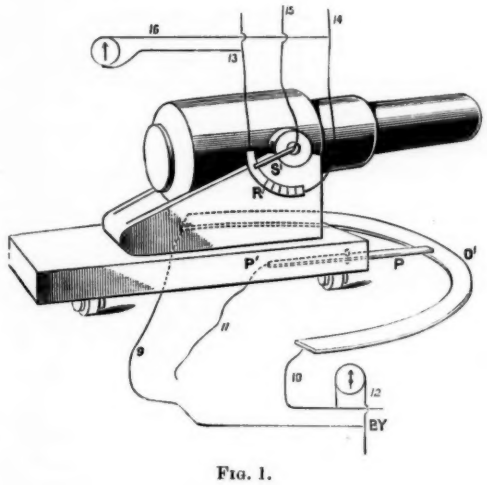


FIG. 1.

M′ is a galvanometer included in loop 8 from the wires 5 and 6. It will be seen that this arrangement of the two arcs, H, H′, and circuit connections, is the same as that of the arcs, G, G′, and associated parts, and that therefore when the arm, L′, is placed at the same angle with reference to the base line, I′, J′, as the telescope L, is placed with reference to the base line I, J, the galvanometer, M′, will show no deflection, and the bridge will balance, as in the preceding case. It follows, therefore, that if the two telescopes, K and L, be sighted upon the target, F, by observers located at the telescopes, and if a third observer moves the arms, K′, L′, and at the same time watches the galvanometers, M, M′, he will have placed the arms, K′, L′, at precisely the same angles as the telescopes, K, L, when both galvanometers show zero reading. Inasmuch as the chart, *a*, *b*, *c*, *d*, bears a definite proportion to the area which includes the position of the target, F, it follows that if the axes of the arms, K′, L′, be prolonged they will intersect at the position, F′, which would represent on the chart the actual position of the target, F.

Upon the chart, *a*, *b*, *c*, *d*, are pivoted three pointers, only one of which, for convenience, is shown at N, and these pointers are pivoted at the points, C′, D′, and E′, which, as already stated, correspond to the centres of horizontal motion or train of the guns, C, D, E. Consequently, if the pointer, N, be turned on its pivot, it will correspond to the positions of the gun, E, when that gun is turned on its pivot.

One arm of the pointer, N, is long enough to sweep over the area which includes the target, and it is connected to the intersection of other pointers by a slotted pivot, so that it is automatically made to point in the direction of the target. At the gun itself is an arc, O′, and pointer, B′, which, by the principle above explained, always shows how the pointer, N, is pointing. The distance from the pivot, E′, to the intersection of the pointers on the chart is marked on the graduated pointer, N, and can at once be signalled to the gun, E, by means of the arc, R and R′, according to the same principle.

Or, if desired, the resistance from E′ to F′ may at once be signalled automatically according to the same principles. The action of the apparatus is much facilitated, however, if the arcs, P and R′, are attached to the gun itself, as shown in fig. 1, so that the gun itself is moved instead of the pointers, and the man in charge of the training of the gun has simply to watch one galvanometer, while the man in charge of the elevating of the gun watches the other galvanometer. It is evident that both of these men can, by keeping the needles of their galvanometer at zero, keep the gun always properly trained and properly elevated, even while it is being loaded, so that the gun will be ready to fire immediately. It is evident that any number of guns, as C and D, may be controlled in the same manner, so that the mere automatic action of the apparatus gives to the men at every gun the most simple and accurate instruction possible as to what they are to do, and that no reading of scales is required.

The *raison d'être* of this invention arises from the fact that the modern guns in Europe are tremendously expensive, some costing $100,000; that each shot is terribly effective, and that it costs hundreds of dollars to fire each shot. It is, therefore, absolutely necessary that there should be no delay in firing, and that each shot should hit the enemy.

THE MACMAHON ELECTRIC CHECK SYSTEM.

IN recent years many devices have been introduced for checking tills and attendants in various business establishments, but owing partly to the complication of the apparatus employed, and partly to unsatisfactory working, such devices have not come greatly into use. At the present time it is an indisputable fact that a large amount of money is annually lost by the proprietors of restaurants, hotels, public houses, and other establishments where beer, wines, spirits, and other liquids are sold. This loss is partly occasioned by the acts of dishonesty practised by some bar attendants, and is partly due to waste of the liquid owing to overdrawing. The former disadvantage has been partially overcome by certain check tills now in use, but the latter defect still remains. It was with a view to entirely surmount these difficulties that Mr. Macmahon turned his attention to the subject, and the result of his experiments was the invention of an electric check system and self-registering apparatus for licensed victuallers, wine and spirit retailers, and public house proprietors. The system was shown in operation for the first time at the Brewer's Exhibition, held at the Agricultural Hall, in October last, when it attracted considerable attention. Since that time the apparatus has been submitted to various tests in order to make it practically perfect and suitable for every form of bar in use.

The invention consists essentially of two parts, one being the measuring apparatus, and the other the instrument which records the amount of liquid sold, both being in electrical communication. The principle of this system is as follows:—If a customer asks for four pennyworth of Irish whiskey, the bar attendant moves a knob along a horizontal slot until it points

to figure 4; he then turns on the tap, and the exact quantity, and not a drop more, is drawn off into a glass or measure, but as the quantity obtained is *exactly* that required, the measure may be dispensed with. At the same time the withdrawal of the whiskey sets up electrical communication between the measure and the registering apparatus, and the amount of the purchase, which in this case was 4d., is added to the total previously recorded. It will be evident that fraud on the one hand, and waste on the other, are absolutely impossible, and the work of the bar tender is reduced to a minimum.

We will now describe the details of the system :—The measuring apparatus has been very ingeniously devised. The liquid to be served is contained in a cask placed above the tap, in any convenient position, and it flows down the pipe to the back of the tap. From here it passes through a short pipe into a cylindrical vessel or bellows, which constitutes the measurer proper. This measurer is made to contain any desired amount of liquid of from one pennyworth to, say, a 1s., or more. Over the top of the measurer or bellows, and down each side of it, is carried a brass rocking cradle in the form of the letter ∪ inverted, thus ∩. The cradle is pivoted on each side at the bottom of the bellows, and the cross-bar of the cradle, in its normal position, is just in contact with the surface of the case enclosing the bellows. Thus, if the cradle be pushed backwards, say, half an inch, the bellows falls by its own weight, and a certain quantity of liquid is forced through the pipe at the bottom into the tap, the amount of which is determined by the extent to which the bellows is lowered.

Commencing at the top on each side of the two upright bars of the cradle is a series of slotted steps, something like an ordinary staircase. These steps are the means by which the quantity of fluid withdrawn from the bellows is automatically regulated, and for this purpose there is provided at the top on each side of the bellows, and pivoted to it, a pin which is automatically caused to fall into any one of the several steps. The action of this cradle and pins will shortly be described. In front of, and just above, the tap or taps in the public bar, is a horizontal slot from which projects a knob, which is connected by a lever to the cross-bar of the cradle. Above the slot are arranged any number of figures, such as 2, 4, 6, 8, these figures indicating the prices, and, therefore, the quantities of liquids sold. Thus, if it is desired to draw four pennyworth of brandy, the knob is placed over the figure 4, and the tap turned. The act of moving the knob to this figure causes the cradle to be pushed back a certain distance, and the bellows pins to fall into the second step on each side of the cradle. Simultaneously, the bellows descends, but only to the extent of the distance permitted by the pins, which, in the case in question, are in the second steps. Thus the exact quantity of liquor, and nothing further, is forced out of the bellows, and even if the tap be left on, no more liquid can be obtained. During this time the supply of liquor from the cask is automatically cut off; but after the desired quantity is drawn from the bellows and the tap closed, the supply is automatically re-established and the bellows again filled for further use. The cutting off and re-establishing of the supply are obtained by a suitable two-way cock.

The electrical part of the measurer is arranged as follows :—In the centre of the bellows is arranged a brass tube grooved spirally, the tube being fixed in the top of the bellows. Inside this tube is a metal stem with a projecting pin, which engages in the spiral groove. This stem passes also through a hole in the casing which covers the bellows. At the top of the stem, and therefore outside the casing, is rivetted a pointer or contact maker. This casing has on its surface an ebonite disc with contacts arranged round the edges. The number of contacts correspond to the different quantities of liquids, and the contacts are electrically connected to the registering apparatus by a dry battery. The measurer acts in the following manner : The fall of the bellows gives to the central stem carrying the pointer a circular motion, and the pointer travels round the ebonite disc, thus making and breaking contact in succession at one or more of the contact pieces, which are let in the ebonite and connected underneath to a common conductor. It is, of course, along this conductor that the current from the battery passes to the electro-magnets of the recorder.

The registering apparatus consists of a pair of vertical electro-magnets and three large brass wheels placed parallel at about $\frac{5}{8}$ths inch apart. The second and third wheels have on their peripheries figures ranging from zero to 20, and the first to 24, the first or left-hand wheel representing pence, the second shillings, and the third pounds. Inside each of these large wheels, and on their axes, is a ratchet wheel, and from the side of the first two of these projects a pin. The pin in the first ratchet wheel engages with the second ratchet wheel, and the pin in the second wheel engages with the third ratchet wheel, the propulsion mechanism being similar to that used in the ordinary tape-printing machine.

Above the poles of the electro-magnets is placed a horizontal armature. On the middle of this armature, and at right angles to it, is rivetted a long brass strip, which terminates in a ratchet engaging with the first ratchet-wheel. (It must here be borne in mind that the first ratchet and first large wheel both correspond to pence, the second two to shillings, and the third to pounds.) On a current from the battery being passed through the electro-magnets, the armature is drawn downwards, and this causes the first ratchet wheel to revolve, which in turn actuates the first large wheel. Each tooth on the first ratchet wheel corresponds to one penny, and on this wheel being turned the distance of one tooth, the large wheel is also moved round one figure. In this case, if the previous record was 5d., the large wheel would indicate 6d. On the first ratchet wheel being turned the distance of 12 teeth, its projecting pin releases the second ratchet wheel, allowing it to turn the distance of one tooth. This causes the second large, or indicator wheel, to travel to figure 1, thus denoting that 1s. has been registered. This operation is repeated until 19s. 11d. has been recorded by the first two wheels. Then, on more liquor being drawn from the tap, the pin on this second wheel releases the third ratchet wheel, allowing it to advance one tooth. This, of course, causes its large wheel to move to figure 1, indicating that £1 has been registered.

Each contact piece represents one penny, and in the recording of four pennyworth of liquor, the pointer or contact-maker would make and break contact four times, that is, with the first four contacts, and the armature would therefore be attracted four times in succession, thus making the ratchet wheel turn the distance of four teeth, and the large wheel to add 4d. to the previous total, and so forth for other amounts. By the arrangement of a lever the three recording wheels can at any time be set at zero. This system of checking and measuring is now in use in several large licensed victuallers' establishments, and a company will shortly be formed to work the system on a large scale.

UNDERGROUND LINES.

IN our issue of March 21st we gave some details regarding the condition of the gutta-percha covered underground wires in Maurienne (Savoie), when overhauled in 1889 by M. Schaeffer. In the January-February number of the *Annales Télégraphiques* M. J. Gidel describes his experiences during repairs effected by him in 1889 to some of the underground lines in the Lyon district.

The lines to which attention is particularly called are those laid in cement conduits—one between Grenoble and Gap, about 100 kilometres in length, composed of two cables; and the other, between Tarare and Roanne, of about 40 kilometres, composed of three cables. Each of the cables contains three conductors, two of small diameter for short-distance signalling, and

the third of a heavier type for working on long circuits. The conductors are of seven copper wires stranded, and insulated with gutta-percha, and the cables have an outer protection of tanned, and in some cases tarred, tape. The cables were laid in 1884.

Great difficulty seems to have been experienced in repairing these lines as they were found to be in a very bad condition, no less than 25 faults being taken out of one section of 500 metres on the Tarare-Roanne system, while between Grenoble and Gap many sections were found to contain from 15 to 20 faults.

On the greater portion of the two lines under notice, the percha was found to be bare, the tapes having become perfectly rotten, and, in many cases, having altogether disappeared. This decay is attributed to the burning of the fibrous material by the caustic elements of the cement dissolved by water in the conduits. Under these conditions, it was found impossible to draw the cables through the conduit, for the purposes of repair, without still further injuring the gutta-percha covering.

All the faults were due to cracks in the percha. The conductor at these places was blackened, and generally very much damaged. A close examination showed that fusion of the metal had taken place, particles of copper had been separated, and on the percha in the vicinity of the faults, small particles of copper were noticed. Frequently two or three of the copper wires were found broken, and, in some cases, all seven.

The routes followed by the lines are through districts subject to the most violent thunderstorms, and, in several instances, it was proved beyond question that lightning had struck the ground, or some object, in the neighbourhood of the cables, at points where faults were discovered. In one case, the course of the lightning was marked by a passage burned through the sandy soil, large enough to admit a ram-rod ; the conduit was blackened at the point struck, and an iron wire in the cement covers to the conduit was reduced to powder.

The majority of these faults, which the author describes as being due to lightning, were, however, not caused by a direct flash, but are attributed to inductive action. Some considerable portion of the lines was also found to suffer from a general weakness ; the loss of current being so great in these localities, that it was necessary to renew the cores. The percha in these situations had been exposed to alternate wet and dry conditions, and had become of a yellow colour to some depth.

At certain places, such as junction boxes, the percha wires are covered with India-rubber tubes. Wherever these tubes fitted the percha so tightly as to prevent the access of air or moisture, the percha completely changed its appearance, turning to a light yellow colour, and becoming quite pasty.

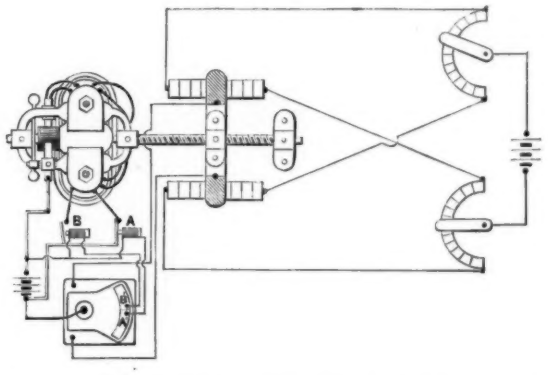
The author draws a comparison between the condition of the cables in cement conduits and those carried in iron pipes. Of the latter, there are several lines in the same district, and equally subject to the visitation of thunderstorms, but no faults have been discovered in them. He therefore comes to the conclusion that the only method which can be adopted to secure the safety of the underground lines is to abandon the present system, and to either lay the lines in iron pipes, or to give the cables an outer protection of iron sheathing wires.

Electrotechnical Course in Naples.—The Italian Minister of Public Instruction has just instituted a practical electrotechnical course in the Practical School in Naples, the instruction in which will be given by Prof. Guido Grassi. The laboratory is provided with all the necessary machinery, and already contains a dynamo, a 10-H.P. motor, numerous measuring and other instruments. The programme comprises : Instruments and methods of measuring electricity, primary and secondary batteries, dynamo-electric machines, distribution and transmission of electrical energy, and electric lighting.

THE FISKE RANGE-FINDER.*

I WAS much interested in the description of the Fiske range-finder, which appeared in *Science* on January 24th. There is much credit due to Lieut. Bradley A. Fiske for the ingenious manner in which he has applied a most beautiful electrical combination to a practical purpose, and there is no doubt that its range of usefulness will extend beyond the realms of gunnery practice.

While reading the article an idea came into my mind, which may also have occurred to Lieut. Fiske, and been rejected as impractical ; yet I think I will speak of it, as I see no reason why it could not be applied with success, and still further increase the effectiveness of the range-finder. The object is to make the range-finder self-recording, to automatically adjust the balance, and to avoid the need of a third operator. The method is extremely simple. First, the "slider" is provided with a nut, through which a spindle revolves, the spindle being the continuation of a small motor-shaft. The fields are wound with two coils in such a manner that, when the circuit is closed through one, the motor revolves in a particular direction, and, when closed through the other, in the opposite direction, moving the slider backward or forward, as the conditions might require, to establish the balance. The motor is fed from one cell of storage, or other battery, at about two volts potential.



The operating mechanism is equally simple. Two small magnets, A and B, are connected to the same cell that supplies the motor, and the return wire of each terminates in a drop of mercury, A′ and B′, located each side of the galvanometer-needle, so that the least movement to one side or the other will cause contact with the globule of mercury. The circuit thus being closed through the needle to the other pole of the battery, the corresponding magnet becomes energised, attracting the armature, which closes the corresponding circuit of the motor. The object of the magnets, A and B, is to reduce the sparking at A′ and B′, and they might possibly be dispensed with. They were to be wound with considerable resistance, that the current might be so small as to prevent any trouble at A′ and B′ by burning or sticking of the contacts.

There are other arrangements whereby the above result might be accomplished, but I send this, as it may be of some interest should this plan of automatically adjusting the balance not have been previously thought of. J. F. DENISON.

New Haven, Conn., *February 15th.*

Telegraphy in Germany.—Statistics have been published showing that though the rates charged for telegrams for long distances in Germany have been greatly reduced since the early days, messages for short distances are dearer now than they were twenty-three years ago. The minimum charge is 60 pfennige, or about 7d. for ten words.

* *Science.*

LIGHTNING CONDUCTORS.

By S. ALFRED VARLEY.

(*Concluded from page* 370.)

EVERYTHING that relates to Leyden arrangements and statical discharges has a very direct bearing when studying the mode of action of lightning. In the last issue certain experiments of Sir W. Thomson were referred to; those experiments went to show that when metal plates arranged parallel to one another, and charged oppositely until discharge occurred, the sparking distance slightly exceeded the difference of the potential of the two plates—that is to say, if a difference of potential = 1 was capable of creating a path through an air space = 1, then a difference of potential = 2 would discharge through an air-space slightly exceeding 2; reference was also made to certain experiments made by the writer with six Leyden jars charged side by side and then suddenly arranged in series, and it was stated that the air-space which these jars charged to the potential at command were capable of breaking down when joined side by side = $\frac{1}{2}$ an inch, but that when connected in series they were capable of breaking down an air-space of 16 inches with certainty, and occasionally 18 inches.

The results obtained by Thomson and those obtained by the writer do not seem at first sight easily reconcilable, and they illustrate the importance of looking at scientific phenomena from several points of view. It is never safe to generalise from a single experiment tried under specially arranged conditions unless a connection can be traced between the results obtained, and other well-established observations, or unless, indeed, they help to throw light upon, and render clearer what has been previously observed.

The writer now proceeds to try and connect his own experiments with those of Sir W. Thomson. It has already been stated that the Leyden jars in the writer's experiments, when arranged side by side, were capable of breaking down an air-space = $\frac{1}{2}$ an inch. Let it be assumed the difference of potential between the inner and outer coatings of the jars which is necessary to break down $\frac{1}{2}$ an inch of space = 1, that the energy which has to be expended to produce such potential in a single jar = 1, and that the quantity of electricity accumulated in each jar = 1 also.

Experiment 1.—Charge a single jar to a potential = 1, the energy expended in charging it will = 1, the quantity of electricity will = 1, and the air-space capable of being broken down will = $\frac{1}{2}$ an inch.

Experiment 2.—Charge a single jar to a potential = 6, the quantity of electricity will = 6, but as the expenditure of energy involved in statically charging Leyden jars increases as the square of the potential, the expenditure of energy will = 36, the difference of potential between the two ends of the air-path will = 6, the length of the air-space capable of being bridged in the act of discharge will = 18 inches, and the quantity of electricity which will pass through the air-path will = 6.

Experiment 3.—Charge 6 jars side by side to a potential = 1, the expenditure of energy will = 6, and the quantity of electricity in the 6 jars will = 6. Now arrange them in series, the difference of potential at the ends of the air-path will = 6, similarly as was the case in Experiment 2, the air-space capable of being bridged will also = 18 inches, but the quantity of electricity which will pass through the air-path will = 1 only.

In Experiment 2, the difference of potential between the two ends of the air-path was = 6, and the quantity of electricity which passed through the air-path was = 6; but in Experiment 3 the quantity of electricity discharged through the air-path was only one-sixth part of that which passed through the air-path in Experiment 2, and the expenditure of energy in charging 6 jars side by side to a potential = 1 (the potential being raised afterwards to 6 by arranging them in series), was only one-sixth of that required to charge a single jar to a potential = 6. The expenditure of energy in charging the single jar (Experiment 2) to a potential = 6, was six times that expended in Experiment 3, and the energy accumulated in the Leyden jar and the energy dissipated at the time of discharge was also six times as great, and, therefore, the writer is of opinion that if the 6 jars arranged in series (Experiment 3) should be capable of deflagrating, say 10 feet of No. 40 B.W.G. iron wire, then the single jar charged to a potential = 6 would deflagrate six ten-foot lengths of No. 40 wire, arranged either side by side, or end to end in one sixty-foot length. The reasons that lead him to the conclusion that under the conditions stated, the length or the section of the wire might be increased indifferently is that the work to be performed would be the same in both cases, and that as electricity has no inertia, and as the disturbing element, viz., internal resistance which occurs both in galvanic batteries and in dynamos is practically absent* when energy is accumulated as statical charge, it can make no difference to energy itself whether it breaks down a given number of molecules arranged side by side or in a continuous length.

Experiment 4.—Arrange 6 Leyden jars in series, as indicated in fig. 14, before charging them. Assume the thickness of the glass separating the inner and outer coatings to be $\frac{1}{10}$th of an inch, then the total thickness of glass separating the + and − conductors of the influence machine will be $\frac{6}{10}$ths of an inch instead of $\frac{1}{10}$th of an inch as is the case when the jars are charged side by side; that being so, it will be found that to accumulate a quantity of electricity in each jar = 1, will involve an expenditure of energy = 6, and, therefore, it will be seen that to accumulate a given quantity of electricity in a number of jars the expenditure of energy will be the same, whether they are joined together, side by side, or arranged in series.

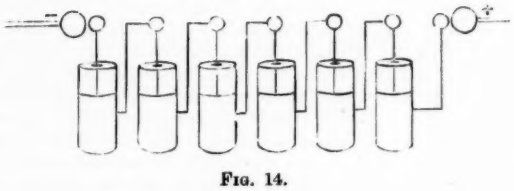


FIG. 14.

Experiment 5.—Construct a Leyden jar of the same internal section as the jars referred to in the previous experiments, but let the thickness of the glass be increased from one-tenth to six-tenths of an inch the thickness of glass separating the + and − conductors of the influence machine will now be the same as that in Experiment 4, and to charge such jar with a quantity of electricity = 1, will involve an expenditure of energy = 6, and the difference of potential between the inner and outer coatings will = 6.† The laws which govern the accumulation of a statical charge in Leyden arrangements has now been analysed step by step, commencing with the charging Leyden jars arranged side by side and in series and charged to varying degrees of potential. In the last experiment (No. 5.) we have arrived at similar conditions to those which prevail in Sir W. Thomson's experiments with flat plates separated by different thicknesses of air-space so far as the charging of such Leyden arrangements are concerned.

It follows from what has been stated that the expenditure of energy involved in accumulating electricity

* The resistance encountered in the tinfoil coatings has not been overlooked, but such resistance in a Leyden jar of large surface or a number of jars arranged side by side is small, and is very much less than when an increase of potential is obtained by arranging Leyden jars in series.

† As the outer surface of a Leyden jar becomes somewhat increased by an increase in the thickness of the glass the capacity is affected a little in consequence, this disturbing element, which does not occur in Leyden arrangements made with flat plates of glass or with an air space (as was the case in Thomson's experiments), has been disregarded.

on the surfaces of a dielectric increases as the square of the quantity accumulated; and, secondly, that when the thickness of the dielectric is increased, the expenditure of energy which is necessary to accumulate a given quantity of electricity increases directly as the thickness of the dielectric is increased. In the writer's own experiments of 1858 with flat plates of glass, it was found that induction decreased directly as the thickness of the dielectric was increased, and that when the difference of potential was maintained constant with a varying thickness of dielectric, the quantity of electricity accumulated on the surfaces of the dielectric was less inversely as the thickness was increased. In Sir W. Thomson's experiments, where discharge occurred between two circular plates separated by an air-space, it was found that if a difference of potential = 1 would discharge through an air-space = 1, then a difference of potential a little less than 2 would discharge through a space = 2. The explanation the writer would give of this observation made by Reiss and confirmed by Thomson, is that the difference of potential is slightly greater in the centre of the plates than in the neighbourhood of their outer diameters; * and although the writer was not aware until very lately of the experiments of Reiss and Thomson, he hails them because they form the key-note of his contention, arrived at by a somewhat different process of reasoning, that currents travel through the centre of conductors, *theoretically*, at a slightly greater rate than through their outer skins.

The results obtained by Sir W. Thomson incidentally confirm the opinion which has been expressed by the writer, viz., that the length of wire a statical discharge is capable of deflagrating is directly as the energy accumulated in the Leyden battery. In a Leyden arrangement, consisting of two parallel plates separated by an air-space, the quantity of electricity at the time discharge occurs is a constant amount, whatever may be the distance the oppositely-charged plates may be separated from one another; † for the energy which is capable of being accumulated in such Leyden arrangements is limited by the resistance opposed by the air-space, and the resistance it opposes is directly as the distance separating the oppositely-charged plates. Now, if the plates be separated from a distance 1 to, say, a distance 3, then three times the energy is required to accumulate the same quantity of electricity, and a further accumulation of electricity is not possible, because three times the energy will break down three times the thickness of air-space.

The results which were obtained by the writer with Leyden jars at first sight do not seem reconcilable with the experiments of Reiss and Thomson. In the writer's experiments with Leyden jars, the air space broken down increased as the square of the potential; in Thomson's experiments, the power to break down air increased directly as the potential was increased. Now, in the case of Leyden jars, the energy increases as the square of the potential, and the power to perform work is directly as the energy. In the Leyden arrangement of Thomson's experiments, the conditions were such that the energy increased *not* as the square but directly as the potential, and the power to break down air space was also directly as the energy.‡ The atmospheric Leyden arrangement of a thunderstorm is of a similar character as the two metal plates separated by an-air space employed in Thomson's experiments, and given the distanee of the thunder clouds from the earth it is easy to estimate approximately the energy per square mile of cloud at the time discharge occurs.

Taking the deflagration experiment recorded by Crosse as a sort of basis to start from, we find that 73 feet of surface charged to a potential not given, but which would probably not leap a greater space than two inches of air, 30 feet of iron wire of about No. 40 B.W.G. were fused. Now if we assume that a Leyden arrangement consisting of two metal plates of 100 square feet of surface, each separated by an air space of two inches would be capable of accumulating a similar quantity of electricity as Crosse's Leyden battery of 73 feet surface, then in every 100 square feet of a charged cloud at the time of discharge to the earth, there would be the same quantity of electricity, and the energy associated with this electricity would be greater directly as the distance separating the clouds from the earth is greater than that separating the two metal plates of the Leyden arrangement of 100 feet square.

It is stated that thunder clouds at the time of discharge are sometimes more than a mile from the earth; but if the distance be assumed to be one mile, then the energy accumulated in every square mile of surface would be about 800,000,000 times that accumulated in Crosse's battery, by which he was able to fuse 30 feet of No. 40 iron wire, and therefore it will be seen that the energy accumulated in thundercloud and dissipated during a thunderstorm must be simply enormous.

The deflagration of wires by Leyden battery discharges cannot be said to have received the attention it deserves. What is observed when conductors are so deflagrated helps, it is thought, to answer a very practical question which can scarcely have failed to have engaged the minds of those who have given thought to the subject, viz., how is it, that, notwithstanding the energy accumulated in thunder clouds and dissipated when discharge occurs, is so great, lightning conductors are seldom, if ever fused.

In thunder-clouds some square miles of surface are charged to a potential by creating a path through a mile, or it may be more, of air-space, and yet as the writer is able to testify from experience, a heavy discharge may occur through a No. 8 galvanised iron telegraph wire without fusing it, whilst on the other hand, as we have been informed, the energy capable of being accumulated in a Leyden battery by a hand-worked machine, which must be relatively as a drop of water to an ocean, is sufficient to fuse a 30-foot length of iron wire, and there would be no difficulty in fusing greater lengths with Leyden batteries charged with the influence machines of the present date.

The explanation of the deflagrating powerlessness of lightning, which seems so wonderful after we have become acquainted with the relatively great deflagrating capabilities of Leyden batteries, has been given already, it is thought, in the explanation suggested of how it comes about, that so small an amount of sensible heat is developed when a statical discharge occurs through the coatings of the Leyden jar and an air space only, compared with that we see evidence of, when a length of wire which forms part of the paths of discharge becomes deflagrated. When a long length of wire is deflagrated by a Leyden battery the conditions may be said to be the very reverse of those that prevail when discharge occurs from the clouds through the air to a lightning conductor. The tinfoil coating of the Leyden jars, is a short conductor of low resistance, and small magnetic inertia, the air-path is also very short, and in the deflagration experiment of Mr. Crosse, which has been referred to, it was probably not more than a half per cent. of the length of the wire deflagrated. Under such circumstances it will be seen that the magnetic inertia of the metallic path, and also its conductive resistance, was relatively considerable to that of the tinfoil coatings of the jars and the air-path, and that being so the greater part of the energy was dissipated in the wire, which was consequently deflagrated.

Now, in thunderstorms the coatings of the Leyden arrangement are the clouds and the surface of the earth, both of which are imperfect electrolytic conductors, whose resistance become increased at the time

* The reasons for this statement will be given further on.

† This statement requires qualification, for in laboratory experiments it is only true within somewhat narrow limits; there is necessarily more or less induction between the two metal plates and neighbouring matter, and the further the plates are separated the greater the induction between the plates and neighbouring matter. What is stated above, it is thought, would be strictly true of plates situated in absolute space, and is fairly true in the case of thunder-clouds many miles in extent.

‡ This, of course, assumes the sectional area of the metal plates to be always the same. The difference between ordinary Leyden jars and the Leyden arrangements employed in Thomson's experiments will be referred to further on.

a discharge occurs, from polarisation occurring. The air-path may be more than a mile in length, whilst the lightning conductor is only a few hundred feet long at the outside, and, therefore, the resistance of the lightning conductor, relatively to that opposed by the other parts of the path of discharge, may be said to be a negligible quantity, and the energy is dissipated almost entirely in breaking down the air-path and overcoming resistance in the clouds and the surface of the earth.

If the coatings of Leyden jars, instead of being made of metal, were made of damp cloth, or even charcoal powder, the writer ventures to think their deflagrating capabilities would be very much reduced, but Leyden jars so constructed would more fairly represent atmospheric Leyden arrangements.

It follows, from what has been said, that the deflagration of metallic conductors involves a certain relationship between the respective resistances opposed by the coatings of the jars, the air-space, and the metal wire deflagrated, and incidentally an explanation is afforded of how it happens that a Leyden discharge, capable of deflagrating a metallic conductor, will deflagrate a considerable length. In the first place, without an air-space a statical charge cannot be accumulated, and it is the air-space which determines the amount of energy accumulated which is dissipated in the act of discharge; and secondly, the wire to be deflagrated must oppose resistance relatively to the other parts of the path, as the dissipation of the energy occurs where resistance is encountered.

It has been suggested in this article that the deflagration of metallic conductors by Leyden battery discharges may be attributable to overcoming cohesive force instead of developing magnetic polarisation, the writer would not have ventured to put forward what may seem a speculative suggestion were it not that its truth or falsehood admits of such easy determination; and it is referred to because it bears on certain developments of the newer electrical theory, a faith in which has led Prof. Lodge to put forward, very confidently, altogether revolutionary doctrines, both as to the mode of action of lightning and also as to the conditions lightning conductors should be designed to fulfil. The following illustration will help to make clear the writer's views: take a thick glass tube, having a straight and perfectly smooth bore, and fire into it a pointed soft lead bullet, the body of which is of a slightly larger diameter than the bore of the tube. Assume that the bullet enters the tube at a rate, say, of 500 feet per second, if the glass tube be sufficiently strong the effect will be to reduce the diameter of the bullet, to slightly lengthen it, and also to check its speed to a certain degree. Now, assume a similar bullet travelling at a rate of, say 100,000 feet or more per second, enters the glass tube, the probability would be that instead of the shape of the bullet becoming sensibly altered the glass tube would be converted into dust somewhat similarly, as if a charge of fulminating powder had been exploded in its interior. An action somewhat analagous to that just described, the writer is disposed to think, may occur when a deflagrating discharge from a Leyden battery takes place through a fine wire.

A metallic conductor has a definite amount of inertia, a definite conductive resistance, and the atoms of its molecules are held together by a definite amount of cohesive force. The quantity of electricity associated with the energy accumulated in a charged Leyden battery is so small, that, if the conditions be such that the discharge is spread over a sensible interval of time, the inertia and also the conductive resistance may be regarded as negligible quantities, but the inertia, and in a less degree, the resistance also, which conductors oppose is by no means negligible in the case of statical discharges and rapid alternations in the direction of electric motion.

Take similar lengths of iron, platina and copper wire, say of No. 40 B.W.G., each of these will oppose a definite amount of magnetic inertia and conductive resistance and the atoms of their molecules will be held together with probably varying degrees of cohesive force.

The conductive resistance of iron and platina may be taken as being the same as one another, and as opposing six times the resistance of a copper wire of the same section, but the magnetic inertia of iron is very much greater than that of either that of copper and platina.

Now, when a wire is deflagrated by a statical discharge, it will, it is thought, be seen that the specific resistance opposed by the wire must play an important part, but what may be its importance relatively to that of the specific magnetic inertia opposed by a conductor in the absence of actual experiment it would be rash, even to attempt to suggest; but assuming that the suggestion, viz., that deflagration is an overcoming cohesive force, instead of developing magnetism, then, an iron wire should be more easily broken down by a statical discharge than a platina wire of a similar section.

Now, although the writer is by no means sure whether an iron wire is more easily deflagrated by a Leyden battery discharge than a platina wire, he feels he might almost stake his reputation, that both iron as well as platina wires could be much more easily burst up by electrical discharges than copper wires of a similar section.

In the paper of Prof. Lodge, read before the Institution of Electrical Engineers in 1889, the following passage occurs:—"Recent advances in electrical theory made it easy for me to see further into the matter than the greater men of the past, and a few simple and easy experiments soon brought the conditions of the problem before me."* Lengthy reasons are given in the paper, too long to quote, in explanation of "the reason why iron is as good or even better than copper for the purpose of conveying currents alternating with great rapidity."

In the Dr. Mann lectures, it is stated that the use of copper for lightning conductors is considered to be doomed, and one of the reasons given for preferring iron is its higher melting point than copper; and, further, when recommending iron in place of copper for lightning conductors, it is stated that "Its inferior conductivity is an advantage in rendering the flash slower, and, therefore, less explosive."

Now, if it be found, as the writer himself is very confident it will be, that an iron wire is more easily broken down by a Leyden battery discharge than a copper wire of a similar section, then it is not too much to say that a theory that leads to the conclusion that copper lightning conductors are more liable to be fused than iron ones, and that "the inferior conductivity of iron is an advantage in rendering the flash slower," is self-condemned, and no amount of mathematical equations or clever calculations of the exact microscopic depth that rapid electrical alternations and lightning discharges penetrate into the outer skin *only* of conductors, *even* when made by Sir W. Thomson, or confident assertions that the central portion of lightning conductors is stolidly inert at the time of a discharge, will set such a theory on its legs again.

A Journalistic Eccentricity.—On page 318, of the last issue of a London industrial weekly, appears a notice that "for latest telegraphic despatches see page 321." On turning to page 321, the reader finds "Foreign telegraphic advices. As we had to publish earlier than usual this week on account of the Easter holidays, we were obliged to go to press without the latest telegraphic despatches from our continental correspondents." This is like the famous descriptive work on the Emerald Isle, which was carefully indexed, and contained in the index the heading "Snakes in Ireland, page 153." On looking up the page in question, there was found one line on the subject, and that ran, "There are no snakes in Ireland."

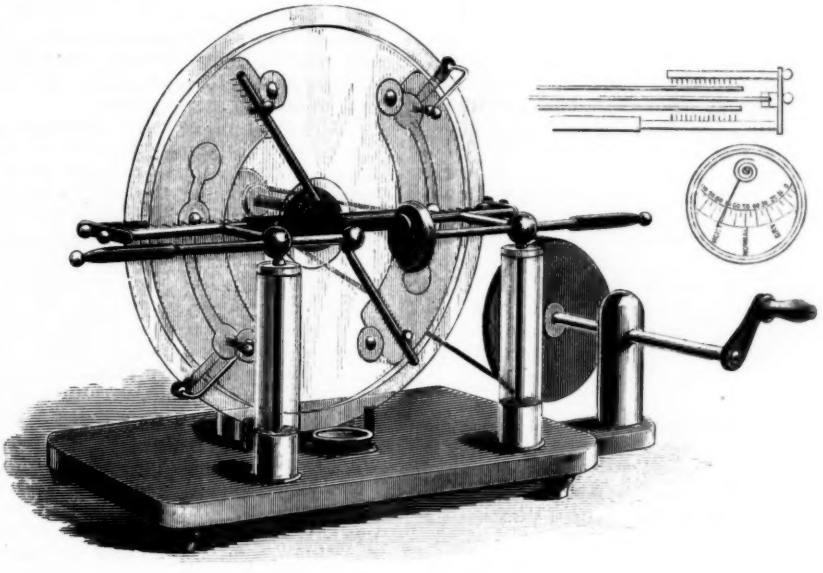
---

* The writer is of opinion that it would be more in accordance with true science to say that recent retrogressions from the simple electrical theories of Franklin and Faraday have led some of our ablest mathematical physicists temporarily astray.

QUEEN'S NEW TRIPLE-PLATE TOEPLER-HOLTZ MACHINE.

ON this page we reproduce a cut from *Science* showing some of the details of the new Toepler-Holtz machine, which has just been patented by James W. Queen & Co., the well-known manufacturers of philosophical apparatus and electrical-test instruments. This machine, unlike very many that have appeared from time to time, is not simply a modification of the orthodox model, embodying certain conveniences, but is an entirely new thing, owing its efficiency to entirely novel ideas of construction and action.

This machine, as its name indicates, is a three-plate machine; it is not, however, the same thing as the machine usually spoken of as the "double revolving plate machine," although it does have two revolving plates. The latter machine is simply an ordinary Toepler-Holtz machine doubled—*i.e.*, with a revolving plate behind the fixed plate, exactly like the one in front and acting in exactly the same manner. In this new form the additional plate is not like the front revolving plate, nor does it act in at all the same way. The third and additional plate is here a perfectly plain glass plate, mounted upon the same axis as the usual revolving plate, and placed behind the fixed plate. Its *modus operandi* is, like many other points in the theory of the Holtz machines, not entirely understood, although there is no doubt but that much of the increased efficiency obtained by its use is due to the screening effects it has upon the other plates—*i.e.*, to the leakage that is prevented by its presence. There is also supposed to be a considerable generation of electricity by friction of the plain plate and the air. Undoubtedly many other causes also tend to increased effects, of possibly even greater importance than those just mentioned. The advantage of this new form of machine becomes especially marked during moist whether. At such times ordinary frictional machines will not work at all; and all older text-books direct that electrical experiments must be performed during January and February, when the weather is clear and dry. With the Toepler-Holtz machine, as now known, this requirement has not been so rigid, although such machines are not to be always trusted during damp seasons, as lecturers have found out to their sorrow. This difficulty it has been desired to do away with in this new form, and that it does it very effectually will be evident from the following letter sent to Queen and Co. by Prof. William A. Anthony, the well-known electrician, and late professor of physics at Cornell University. Says he, "Below is a report of the small Holtz machines you sent up a few days ago. First, in order to determine whether the extra plate gave any increased effect to the machine, I set up both machines, and arranged them so that they both could be revolved by means of one crank, and so that they would both run at the same speed, and then adjusted the terminals until the sparks occurred with about the same frequency in both. Then I removed the combs from one of them, so that the third plate would have no effect in the development of electricity, and found that the frequency of sparks on that machine was very much less than on the other. I repeated this several times, with the same result, and tried the same experiment on the other machine; that is, leaving the combs on the first machine, I removed them from the second, when that one was found to give considerably less electricity than the first. I can say unhesitatingly, therefore, that the addition of the third plate does very much increase the rate of discharge, and, as nearly as I could tell by this rough experiment, about double the rate.



"In regard to the general action of the machine, I can say that I have never seen any machines of the Holtz or Toepler-Holtz pattern that worked so uniformly well in all weathers. One of these machines has been standing on the table here in the office for several days, and I have tried it almost every day, and have never had it fail to generate. During some of the time it has been here, the weather has been very damp and rainy—sometimes so damp that I did not expect the machine to work at all—but I have never found it fail to build up quickly, and give a spark 2 inches long. [This was one of the smallest-sized machines.] This shows that you have succeeded in finding some very good glass, and also that the insulation of the various parts is of the very best. The addition of the round disc, with the insulator in front of it, as one of the electrodes, is also a very interesting one, as it permits of one of the best experiments that I have ever seen for showing the difference in the discharge when the polarity is reversed. The difference in the character of the discharge from the knob is very marked when the knob changes from positive to negative. I may say, therefore, that I consider all the special features of the machine as distinct and important improvements."

Another great improvement that is made in this machine is the form of the electrode which is used. This is made of a metallic disc 2 inches or more in diameter, and hollow, so as to have very gradually rounded edges, thus preventing any leakage at the edges. Over this disc, separated from it by about an eighth of an inch, and nearer the other electrode, is fastened a thin disc of vulcanised rubber about half an inch less in diameter. This rubber disc plays the part of the rubber sheet sometimes held between the electrodes, and compels a much higher potential to be established between the two electrodes before a spark can pass. It can be used upon either one or both electrodes, as desired.

These new machines are being sold by Messrs. Queen and Co. at the same price as the ordinary form heretofore used, and are gotten up in the finest possible manner. It may be mentioned, also, that the plates used in Messrs. Queen & Co.'s machines are manufactured and prepared by Voss himself, the inventor of what is usually known as the Toepler-Holtz machine, and are guaranteed to give much finer and more reliable results than any plates made in the American market. There are certain little tricks of the manufacture and application of the insulating shellac which Americans have not yet mastered, pursued by the Germans to perfection, and which add greatly to the efficiency of the machine.

It may not be generally known that Messrs. Queen and Co. were the first to introduce the Toepler-Holtz machine into this country.

In 1880 the manager of their physical department, Joseph J. Walton, while on a business trip abroad, accidentally learned of the existence of this machine, examined it, and was so favourably impressed by it that he purchased a number for introduction into this country. This was the first appearance of the now well-known Toepler-Holtz machine in the United States. It was exhibited soon afterwards by the before-mentioned gentleman at the meeting of the American Association for the Advancement of Science, and attracted much attention. It immediately became popular, and had such a large sale that it was straightway copied by various American makers, and patents secured upon modified forms.

THE FALLS OF THE CLYDE AS A SOURCE OF POWER.

WITH reference to our remarks on the above in our issue of the 28th we have received the following :—

Roughly there comes down the Clyde Falls, during the whole year, 30,000,000 horse-power hours, taking Mr. Bateman's rainfall estimate, and allowing 33⅓ per cent. for evaporation, &c., and 66⅔ per cent. loss between dam and dynamo, which are moderate estimates (Mr. Bateman's figures are worthy of very great respect, for apart from his being one of our most distinguished civil engineers, his estimates have been wonderfully verified in the Loch Katrine and other Glasgow Waterworks). There is storage room above the falls for every cubic foot of water that falls during the whole year. But storage sufficient to enable the whole of the rainfall to be utilised, *estimates of which are based on the rainfall day by day throughout the year, being impounded and used, so that the consumption would agree with the actual curves of consumption at the Glasgow Gasworks*, would only require $\frac{1}{10}$th the capacity of aggregate fall. If works were erected that would enable this thirty million horse-power hours to be sold, and if it is assumed farther, that one penny per H.P. hour (less 1½d. per Board of Trade unit) could be obtained. This would give a revenue of £125,000. Labour would be very much less with turbines than with steam boilers and engines, and wages would be much under the odd £125,000. But supposing working expenses did come to this figure, £100,000 would be left for depreciation and dividend. Now estimates, allowing depreciation on machinery and conductors at 7½ per cent., and on embankments, &c., at 2½ per cent., show that a dividend of 6½ per cent., and sinking fund at 1 per cent., would be got on a capital more than sufficient to carry out the whole thing. And estimates for fractional parts of the power, down to a plant capable of supplying, say 3,000 H.P. as a maximum, would almost be as favourable, provided the landowners did not insist on the purchase of more land than would be required at first.

The calculation of the power given out by the falls is as follows :—

From the top of the Bonnington to the foot of Stonebyres Falls there is a difference in level of about 222 feet, and if a dam were made at the highest point for storing the water, every foot of height in the embankment would add to the available head. Theoretically, every pound of water falling this distance represents 222 foot pounds of energy, but in practice it is impossible to obtain anything like that, even when the fall is truely vertical. The water would require to be run from the highest to the lowest point in pipes, and the friction would cause a loss of pressure, but this could be minimised by using large pipes ; and the loss in turbine and dynamo could be kept low by using the best types of each, and working them as near full load as possible. Assume that two-thirds of the power is wasted in that way, then a stream passing through a turbine at the rate of one cubic foot per second would give somewhat less than eight-and-a-half electrical horse-power ; ten cubic feet per second would give ten times as much, and so on, according to the quantity of water passing.

The extent of country drained by that part of the Clyde is slightly over 250,000 acres. Mr. Bateman estimated the annual rainfall in the district at 44 inches, and making the usual allowances for evaporation and absorption, 30 inches is carried away by the river. In other words, the water that comes tumbling over the falls during a year would cover 250,000 acres to a depth of 2½ feet ; and allowing the moderate figure of 8½ horse-power per cubic foot per second would give nearly 18,000 horse-power continuously for ten hours daily throughout the year. There would, perhaps, be very little rain in the three summer months, but, on the other hand, very little artificial light and heat would then be required. A reservoir, however, would certainly require to be erected if machinery with, say 10,000 horse-power, were erected. A storage basin at Hyndford Bridge, to hold 415,000,000 cubic feet, would cost £150,000—well on to which sum the Gas Commissioners pay per annum for coal just now—and this quantity of water would give 2,200 horse-power for nearly three months five hours daily, even supposing no rain were to fall all that time, and with the further unlikely supposition that all the natural streams flowing into the reservoir would be required to compensate for the evaporation.

ELECTRICAL CALCULATIONS.*

By T. O'CONOR SLOANE, Ph.D.

I AND II.

THE readers of this paper often send questions as to the battery required to do different kinds of work. It is believed that a few words on the subject will be appreciated by them.

In fixing the requirements in any case of electrical supply, three factors are concerned, the maximum difference of potential in the circuit, or the electromotive force, the resistance of the circuit and the current required. Any two of these being given, the third is deducible by Ohm's law, which may be thus expressed :

* *Scientific American.*

The current, C, given or required is equal to the electromotive force or difference of potential, E, divided by the resistance, R. $\left(C = \frac{E}{R}\right)$ Ampères, volts, and ohms are generally used as the units of current, of potential or electromotive force, and of resistance respectively.

In considering the battery to be used, we must have regard, *a*, to the minimum number of cells that will do the work, and to their arrangement, or, *b*, to the proper number of cells to work economically. As regards the latter, it may be said that, theoretically, the more cells we use, the more economical will be their working. We can apply practical considerations only in determining the economical number, because of the fact stated in the preceding sentence. We may first consider case *a*.

A battery cell is rated by its resistance and electromotive force. Dividing the last by the first, we get the current it can give through an external resistance equal to zero, or infinitely small. Multiplying such current by E.M.F. (electromotive force), we obtain the energy which it can develop through such a circuit, such energy being expressed in volt-ampères or watts. Suppose a battery giving two volts E.M.F. with a resistance of $\frac{1}{4}$ ohm. Its current through zero resistance is equal to $\frac{2}{\frac{1}{4}}$ or 8 ampères. The energy it can develop through zero external resistance is equal, therefore, to 8 ampères, multiplied by 2 volts = 16 volt-ampères or watts. To ascertain the energy absorbed by any appliance, a lamp for instance, the same calculation is gone through. A 100-volt lamp of 30 ohms resistance requires a current of $\frac{100}{30} = 3\frac{1}{3}$ ampères, absorbing 100 volts multiplied by $3\frac{1}{3}$ ampères = $333\frac{1}{3}$ watts of energy.

The general rule for determining the minimum number of cells required per lamp, &c., to be supplied may be thus stated: Divide the energy absorbed in a single lamp or other apparatus by one quarter of the energy of a single battery cell as determined above; both energies being expressed in watts. The quotient is the smallest number of cells that will do the work. In the case cited in the preceding paragraph the lamp energy is $333\frac{1}{3}$ watts. One quarter of the battery cell energy is $\frac{16}{4} = 4$ watts. Dividing $333\frac{1}{3}$ by 4, we obtain $83\frac{1}{3}$ cells as the number required.

This rule is derived from the following considerations. If a current is passing through a circuit, energy is expended on any portion of the circuit in proportion to its resistance. If, therefore, a battery supplies an external circuit of resistance equal to its own, one-half the energy is expended in the battery and one-half in the external circuit. But the total current or energy expended on the whole circuit is equal to one-half that which the battery could develop with an external circuit of zero resistance. Therefore, the external circuit (lamp or other appliance) receives only one-quarter of the sum of the energies of the cells when calculated as short circuited.

A less abstract way may be taken to reach the same result. A given battery does the maximum work when its internal resistance is equal to the resistance of the external circuit. By its internal resistance it acts as a rheostat. To force a given current through a lamp or other appliance and through its own cells, double the voltage is required that would supply the lamp alone, because the resistance of the battery in addition to the external resistance has to be overcome. Hence, double the cells required to give the voltage of the lamp have to be placed in series, and as this doubles the resistance, the number of cells has again to be doubled in order to form a parallel circuit, thereby reproducing the original resistance. This quadruples the battery, and the rule embodies this multiplication of the cells.

This rule is of interest, as it is so general. But where a definite voltage and ampèrage are to be supplied, it does not always apply. Thus, it gives the minimum battery required per lamp where a number are to be supplied, but not necessarily the number required for a single lamp only. The following rule is simple and of general applicability:

Express the ratio of resistance to voltage in the appliance to be supplied and call it $1 : n$. Do the same for one cell of the battery. If it is $1 : 2n$ or $1 : 3n$; that is to say twice as great, or more than twice as great, as that of the outer circuit, lamps, &c., the cells of the battery must be arranged in a single series in number deduced by the following rule: The number of cells equals the ampèrage of the outer circuit (lamp or other appliances) multiplied by the resistance of the same outer circuit divided by the difference between the voltage of a single cell and the product of the ampèrage of the outer circuit by the resistance of a single cell. Using small letters for the cell constants, and large ones for the outer circuit constants, the formula is thus expressed: Number of cells $= \frac{C\,R}{e - C\,r}$. If the cell ratio is less than $1 : 2n$, then, by placing two or more cells in parallel, a group can be made which will satisfy exactly or exceed as little as possible this ratio. Then the formula given is to be applied to such group exactly as if it was a single cell.

Suppose a 100 volt $3\frac{1}{3}$ ampère lamp is to be supplied. The resistance of such a lamp is found by dividing 100 by $3\frac{1}{3}$, giving 30 ohms. Suppose it is to be supplied by a battery of cells, each of 2 volts electromotive force and $\frac{1}{4}$ ohm resistance. The lamp ratio of resistance to voltage is 30 : 100 or $1 : 3\frac{1}{3}$. The battery cell ratio is $\frac{1}{4} : 2$ or $1 : 8$. This latter being more than twice as great as the lamp ratio, the cells must be placed in series by the formula: Number of cells $= \frac{C\,R}{e - C\,r}$, or $\frac{3\frac{1}{3} \times 30}{2 - (3\frac{1}{3} \times \frac{1}{4})} = \frac{100}{2 - 0{\cdot}833} = \frac{100}{1{\cdot}166}$ or $85\frac{5}{10}$ cells. To test the accuracy of the work, we may apply Ohm's law. $C = \frac{E}{R + R'}$ 86 cells give E = 172 volts R′ = $21\frac{1}{2}$ ohms. R we know is 30 ohms. Substituting these in the formula, we have $C = \frac{172}{30 + 21\frac{1}{2}} = 3{\cdot}34$ ampères. A slight excess of current is given, as we have taken $\frac{2}{10}$ of a cell too much, which is unavoidable.

Next assume the same lamp to be supplied by a battery of the following cell constants: $e = 1$ $r = 8$ $c = \frac{1}{8}$. The battery cell ratio of r to e is 8 : 1 or $1 : \frac{1}{8}$. Fifty-four such cells placed in parallel will reduce the resistance to $\frac{1}{54}$ this amount, or the resistance of the group will be expressed by $\frac{8}{54}$ ohm, giving the ratio $\frac{8}{54} : 1$ or $1 : 6{\cdot}675$. Applying the formula to this group, whose electromotive force is still 1 volt, we have: Number of groups $= \frac{3\frac{1}{3} \times 30}{1 - (3\frac{1}{3} \times \frac{8}{54})} = \frac{100}{0{\cdot}506} = 200$ groups in series, nearly; or 54 cells in parallel and 200 cells in series, a total of 10,800 cells. Testing the correctness of our work by Ohm's law, we have current $= \frac{200}{28{\cdot}5 + 30}$ or 3·4 ampères, again a slight increase over that required.

We have seen how to calculate the minimum number of cells of any given battery to supply a specified current through a specified resistance. This is what we termed case *a*. The next thing to be determined is what number of cells should be used to give a fair economy in the consumption of zinc and chemicals. This we have called case *b*.

Where the resistance of the battery is equal to that of the outer circuit, 50 per cent. of the energy will be wasted in overcoming the resistance of the battery. If the battery has one-fourth the resistance of the outer circuit, only 20 per cent. of energy will be wasted. This may be taken as a fair economy, and the calculations for such a battery are the following:—

Divide the resistance of the outer circuit by 4; this gives the proper resistance of the battery. Multiply

the resistance of the outer circuit by the current to be maintained, and increase the product by one-fourth of itself; this gives the proper E.M.F. of the battery. The cells are then to be arranged to develop these quantities, as follows:—

Enough cells are put in series to give the E.M.F. called for. This number is then multiplied by the known resistance of a single cell, and the product is divided by the proper resistance of the battery. The quotient is the number of cells to be put in parallel.

Assume as before that on the outer circuit a current of $3\frac{1}{3}$ ampères has to be supplied through a resistance of 30 ohms. Assume a battery, one cell of which has an E.M.F. of 2 volts and resistance of 1 ohm. Following the rule just given, divide 30 by 4, giving $7\frac{1}{2}$ ohms as the final battery resistance. Next multiply 30 by $3\frac{1}{3}$, giving 100, and increase this by $\frac{100}{4} = 25$, giving 125 volts as the final E.M.F. of our battery. To develop this voltage, $\frac{125}{2}$ cells are needed in series, giving $62\frac{1}{2}$ cells, or say 63 cells. Multiplying this number by 1 ohm, the resistance of a single cell, and dividing by the final battery resistance, $7\frac{1}{2}$ ohms, we have 8·4 cells in parallel $\left(\frac{63 \times 1}{7\frac{1}{2}} = 8{\cdot}4\right)$. Therefore we put 9 cells in parallel, as wherever a relatively small fraction of a cell is called for, it is well to put in an excess. Our total cells, therefore, are $9 \times 63 = 567$ cells. As combined the E.M.F. is 125 volts, the resistance is 7 ohms. Applying Ohm's law to prove our work, we have $C = \frac{E}{R + R'}$ or $\frac{125}{30 + 7} = 3{\cdot}4$ ampères nearly, or a slight excess of current.

This seems a large number of cells, but economical results cannot be attained with a small quantity of high resistance cells. We may, to illustrate this fact, apply these calculations to two other batteries, assuming the same outer circuit constants in both cases.

Let one high resistance battery have the following cell constants: $e = 1$ volt; $r = 3$ ohms. To develop the 125 volts called for, 125 cells in series are needed. To reduce the resistance to $7\frac{1}{2}$ ohms, we need 50 cells in parallel, $\left(\frac{125 \times 3}{7\frac{1}{2}} = 50\right)$ giving a total of 6,250 cells.

Let the other battery have the following constants: $e = 2$ volts; $r = \frac{1}{4}$ ohm. To develop 125 volts, 63 cells in series are needed. To give $7\frac{1}{2}$ ohms resistance we need 2 cells $\left(\frac{63 \times \frac{1}{4}}{7\frac{1}{2}} = 2\right)$ in parallel, giving a total of only 126 cells.

This shows the importance of a low resistance ratio compared to voltage. Practically, a high resistance battery cannot be used for heavy work. Low resistance may even compensate for low voltage, as in the oxide of copper—caustic soda battery.

Taking a battery of the constants, $e = 2$ volts, $r = \frac{1}{6}$ ohm, it will be found that $1\frac{1}{4}$ cells are needed in parallel for the above conditions. As this is impossible, and as the fraction is relatively too large to neglect, the best plan in such a case is to take the next highest integral number for the cells in parallel and reduce the number of cells in series. Thus, instead of $1\frac{1}{4}$ cells take 2 cells in parallel, and calculate the constants of such group. They are in this case $e = 2$ volts, $r = \frac{1}{12}$ ohm. Applying the rule given in the former article we have: Number of groups $= \frac{C R}{e - C r}$ or $\frac{3\frac{1}{3} \times 30}{2 - (3\frac{1}{3} \times \frac{1}{12})}$ $= 58$ cells in series and 2 in parallel, a total of 116 cells. Applying Ohm's law to test our work, we have $C = \frac{116}{30 + 4{\cdot}8} = 3{\cdot}3$ ampères. The economy in chemicals and zinc is increased by this procedure, the waste energy being only $\frac{4{\cdot}8}{34{\cdot}8}$ or about 14 per cent.

THE TEMPERATURE COEFFICIENT OF SWAN LAMPS.

As very few observations have been made as yet upon the temperature coefficients of the resistance of incandescent lamps, the following results will, writes Herr F. Uppenborn in *La Lumière Electrique*, doubtless be of interest.

In measuring the resistance of lamps whose temperature varied considerably, a bath of linseed oil was made use of. The lamp experimented upon was attached to an agitator capable of being seesawed up and down and down and up inside a Bohemian glass full of oil suspended within an enamelled pot, which was likewise furnished with an agitator. The oil being at boiling point the pot was placed inside a box containing sawdust, and the resistance measured at intervals whilst it cooled. By immersing a nitrogen thermometer in the glass jar the temperature of the incandescent lamp was ascertained. Some difficulty was met with in establishing contact between the lamp and the wire used for taking the measurements, and it was only possible to make use of lamps with platinum hooks; and the contact of the latter with the copper wires was obtained by means of a galvanoplastic deposit.

The measurements still presented some difficulty owing to the lamp's resistance not being constant. This was owing to the heating of the wires by the current which served as the measure, notwithstanding that the latter was furnished merely by a Leclanché element, and was assuredly very slight. The difficulty, however, was avoided by inserting a great resistance in the battery circuit, and the results so obtained are given below:—

I.

Lamp's Temperature. Degrees.	Resistance ohms.
300·0	51·003
273·0	51·826
245·0	52·688
209·0	53 834
175·0	54·982
137·5	56·174
22·5	59 492
20·0	59·560

II.

286·2	100·10
284·5	100·19
282·0	100·60
254·0	104·70
251·5	105·05
250·5	105·15
210·0	111·15
209 0	111·35
208·5	111·40
165·0	117·80
164·0	117·94
163·0	114·40
114·5	125·34
113·0	125·54
112·0	125·75
70·2	131·85
68·6	132·05
68·0	135·25
47·5	135·25
46·0	139·14
20 6	139·24
20·1	139·34
19 6	—

By turning these observations into a system of co-ordinates, it was found that they could be exactly combined by means of the formulæ—

$$y = a + b\,x.$$

The temperature coefficient, referred to the resistance at 20°, is

0·000513

as regards Table I., and

0·001056

in the case of Table II.

The two lamps were apparently of English manufacture.

NOTES.

Birmingham Lighting.—At a recent meeting of the City Council, the Mayor moved that the Victoria Courts be lighted by electricity. Mr. W. F. Green said he hoped an opportunity would be given to the gas department to see what they could do in lighting the courts with gas. It had already laid down permanent fittings costing £750. Then he argued that the electric light could not be relied upon, and moved that the question be referred to the General Purposes Committee for reconsideration, the amendment being seconded by Mr. Osler, who remarked that he had never yet seen a large room adequately lighted by the incandescent light. Mr. Oliver Pemberton said the unpleasant heating of the Courts was inseparable from the burning of gas under any circumstances. There was nothing so destructive to the binding of books as gas. Alderman Manton considered the electric light would not be a sufficient guarantee in the Courts, and that they would have to lay down gas services as well. Alderman Johnson said other and larger buildings were entirely dependent on the electric light. Finally the resolution was carried by a large majority. The *Birmingham Daily Post* is by no means disposed to quarrel with this decision, but thinks there is a good deal to be said for the argument, that it is hard upon the gas committee not to have the opportunity of showing what can be done with gas lighting by the best methods. As regards the larger question which was incidentally raised by the discussion, namely, whether the time has not arrived for the Corporation to undertake the supply of electric light as well as gas, our contemporary remarks that the experimental stage is undoubtedly passed; electric lighting is a proved and certain success, but the way is blocked by the concession of the best area in the town to a private company, so that if the Corporation were to try its hand at electric lighting it would have to do so under conditions much less favourable to success than if it had the whole of the town from which to choose its area of experiment. It might, the *Post* thinks, be worth while to do that, instead of granting further concessions, if only to ascertain how far any possible influence of electric lighting in competition with gas may be minimised. Valuable evidence as to the advisability of any such movement will be afforded by the experience of the electric lighting company.

Smyrna Lighting.—As the contract with the gas company expires on May 1st, an attempt is being made to introduce the electric light. Unfortunately for the authorities, the question admits of none of the delay which is so dear to the Ottoman mind. Since it would be impossible to depend on moonshine, even in the East, the would-be concessionary has been warned to have 600 lamps in readiness for the fatal first.

Electric Lighting at Beckenham.—The representatives of the Beckenham Local Board have had a conference between the Board of Trade and the promoters of the Crystal Palace District Electric Lighting order, and a satisfactory arrangement was come to, with the exception of one of the clauses which had reference to the transferring of the order. The Board of Trade absolutely prohibited the assignment of the order. Upon the question of purchasing powers it was finally agreed that a clause should be inserted by which the Beckenham Local Board will have the right of purchase after a period of seven years and within 15 years, with the addition of 33 per cent. on the undertaking, the power of purchase being left entirely to the option of the Board.

India Lighting.—The Governor of India contemplates taking in hand the electric lighting of Secunderabad, one of the largest and most important of its military cantonments.

The International Telegraphic Congress.—In the French Chamber of Deputies last week, the credit of 100,000 francs for the expenses of the International Telegraphic Congress was discussed. M. Labrousse said that there were many buildings in Paris where this Congress could be received, without spending 40,000 francs to alter a hall at the Louvre. M. Jules Roche, Minister of Commerce, said that 100,000 francs was not an excessive sum. This Congress was of great importance. Five years since, it was received in Berlin with an ostentation which it was not intended to imitate; still, the reception must be suitable. M. Clémenceau proposed a reduction of 30,000 francs. M. Bastid, reporter on the measure, said it was urgent to vote the credit for a Congress which opened in May. The Budget Commission could only invite the Goverment to seek a less costly installation; but it was proper to leave it a certain margin. He asked that the matter should be referred to a committee, which was agreed to. On the following day the credit of 80,000 francs was adopted by 198 against 0.

The Spanish Colonies of Cuba, Porto-Rico and the Philippines will apply for admission to the International Union. Negotiations are on foot between the Spanish Government and the telegraphic submarine companies in these colonies, with a view to the establishment of more favourable tariffs.

The conference opens on the 5th May in Paris, the riding school of the late Prince Imperial at the Louvre being the place chosen for the meeting.

Rats.—The Americans have settled to execute criminals by electricity, and they are going to execute rats similarly. An American industrial paper gives an account of the *modus operandi*, and as the beauty of the language would be lost by translation into plain English, we give the paragraph as it stands: "Victor Poissant, a young electrician of Omaha, has a very ingenious way of killing rats. The prying rodent is caught in an ordinary oval trap, the bottom of which is covered with tin. Mr. Poissant has a small dynamo of his own manufacture. One wire connecting with the dynamo is fastened to the tin lining of the trap, and another is thrust into the prisoner's cell. The well known propensity of a caged rat to do battle asserts itself, and he seizes the wire between his teeth. In so doing he makes the mistake of his life. The circuit is complete, his jaws close on the wire with a death grip, and without a squeak and almost without a quiver he passes into a state of eternal desuetude." The eternal desuetude of the rat reads superbly, but the whole process is suggestive of catching sparrows by sprinkling salt upon their tails. The terriers in the States will have a just cause of complaint if Mr. Poissant's plan is adopted.

Mr. Edison.—Next month Mr. Edison will start on a six months' tour in Europe. He will visit, among other places, Vienna, Budapest, Constantinople, and the East.

The Electric Light in Sugar Factories.—A correspondent, writing from Huy (Belgium), says:—"The electric light is every day making fresh conquests in our country. Last year the large central factories of Wanze had an installation set up as a trial. The important advantages and economy of this form of lighting have led the directors to decide on installing it in its ten works. These installations have been entrusted to a Brussels firm, Bouckaert & Co.

The Electric Light in Brussels.—At the last meeting of the Brussels' Communal Council, M. Marting inquired whether the Council would not soon consider the question of the electric lighting of Brussels. M. Janssens, in reply, said that different communications on the subject had been received, and these communications would be transmitted to the Electricity Committee, which would then draw up its report and submit it to the Council.

Incandescent Lamps in France.—One of our French contemporaries asserts that for some time past the life of glow lamps has been found to have sensibly diminished. This is attributed by some to the influenza, by others to the fact that there is only the Edison-Swan Company in France, and which has no competitors.

Electric Light in Ireland.—Galway and Drogheda intend to adopt electric lighting in the streets.

Applied Mechanics.—Mr. T. Jones, teacher of engineering at the Central Board School, Manchester, has published a series of plates for students' use in connection with lectures on the above subject.

Internationale Druckluft und Electricitäts Gesellschaft.—This company has been registered in Germany with a capital of £1,500,000, to work the Popp compressed air system. Prof. Riedler, of Berlin, has been lecturing on the subject of the system at Offenbach, and the company have applied to the municipal authorities there for permission to establish a station.

Telephony in Germany.—The postal authorities were recently petitioned by the Chamber of Commerce at Frankfort-on-the-Maine to establish telephonic communication between various of the leading commercial towns of Southern Germany, including Frankfort, Coblenz, Cassel, Mannheim, Würzburg, Nuremberg, Munich, and Augsburg. A favourable reply has been received, and negotiations are proceeding with the interested telephone administrations.

Underground Telegraph Wires.—It is pretty generally known that partly for military reasons and partly to prevent breakdowns when storms take place, Germany has established a net work of underground wires, which connect the leading commercial centres, seaport towns, and fortresses. Up to the present, however, Bavaria has not taken part in this arrangement, but a Bill is about to be presented to the Diet, providing for a very complete system, which will connect Munich, Hof, Dresden and Berlin.

Electric Lighting Units.—The other night in the Association Rooms, St. Andrew Square, Edinburgh, Mr. Colen M. Gardener, District Manager National Telephone Company, Galashiels, delivered a lecture on "Electric Lighting Units" before the Electrical Mutual Improvement Association.

Electric Launches.—The four launches which we said last week would run in the canal at Edinburgh during the Exhibition are designed by Messrs. Morton and Williamson, and built by T. B. Seath & Co., Glasgow. They have a carrying capacity of 40 passengers each, and the electrical equipment has been supplied by Messrs. M. Immisch and Co., London, and is similar to that used on the Thames launches. The charging plant will consist of a 25-H.P. engine and an Immisch dynamo, with suitable switch arrangements for charging four launches at the same time. The motors are capable of an output of about 3½ B.H.P., at 800 revolutions per minute, and the propellers are coupled direct to the motor shafts. A ball thrust-bearing is attached to the motor bed and is constructed in combination with the plain-bearing of the motor. This arrangement is the invention of Messrs. M. Immisch & Co., and has been patented by them. By its use the friction is reduced to a minimum, and there is no noise or vibration. The high speed propellers have been made after a careful course of experiments, and give the highest efficiency hitherto attained with such small blades. They are designed for going both ahead and astern. The steering, starting and reversing gear is so arranged that one man has the launch entirely under control.

Electric Traction Progress.—An electric railway will be laid between Baden and Vöslau in Austria.

The Schiséophone.—A remarkable paragraph appears in the *Colliery Guardian* of last week, stating that "an electrical and mechanical instrument" of the above name has been tested at Ermont, on the Northern Railway of France, which indicates any flaws in the interior of iron and steel with marvellous accuracy. We should much like to know how it is done.

The Thomson Electric Welding Process.—The provisional English company formed to show this system will shortly bring out a large company to exploit the process in England with a capital of £460,000, this sum including, we believe, the patent rights also for the European continent. It is remarkable that the American company was formed with a capital of only £300,000.

Telephonic Communication for Gainsbro'.—It is more than likely, owing to the recent efforts made by leading tradesmen, that the National Telephone Company will shortly extend their wires to Gainsbro', in which event the town will be put in direct communication with Liverpool, Grantham, Sheffield, Leeds, Hull, Retford, Nottingham, Manchester, &c.

New Engine Packing.—Messrs. David Moseley and Sons, of Manchester, have introduced a new patented engine packing, to which they have applied the trade mark "Duriflex." The object of the manufacturers has been to combine the durability of a metallic packing with the flexibility of a fibrous packing. It is especially applicable for marine work and for other uses where long runs are a necessity, and for such purposes it has, in the opinion of the engineers, shown itself superior to any other packing. The packing is constructed in a peculiar manner from wire gauze and a fibrous material such as asbestos or cotton, and, from the nature of its construction, it follows that it must possess the qualities of durability and flexibility in a high degree.

Laying of Mains.—On Thursday of last week the St. George's (Hanover Square) Vestry sanctioned the laying of electric mains by the Westminster Electric Supply Corporation, Limited, throughout the parish, under the footways, upon condition that if any of the inhabitants in front of whose property the lines are laid obtain the sanction of the vestry for the construction of vaults under the footway, the Corporation shall, after one month's notice from such inhabitant, remove the main into the carriage-way to enable the vault to be constructed, and that in future similar applications be granted subject to a similar condition.

Another Storage Battery Decision.—Judge Coxe's decision in the case of the Electrical Accumulator Company *v.* The Julien Company, both of New York, has become a matter of history, and our readers will remember the satisfaction it seemed to have caused to both litigants; the holders of the Faure patents obtaining priority in using "paste, paint or cement," and the Julien Company rejoicing that they were permitted to fill their perforated plates with the dry oxide in the form of powder. Indeed the Julien Company subsequently published statements that their batteries made in the new way (the one which evaded the patent claims of Faure) were superior to anything they ever made before. Judge Coxe has now had another suit before him, the Brush Electric Company against the Julien Company, in which the plaintiff's claims are in the main sustained. Another similar suit is pending between the Brush Electric Company and the Electrical Accumulator Company, and it appears that Brush is in a fair way of establishing a wider monopoly than Faure ever dreamt of possessing. The storage battery industry of the United States is in a turmoil of agitation, or in the words of one of our American friends, "All the storage companies in the United States are at present in the 'soup,' to use a slang expression."

Edinburgh International Electrical Exhibition.—Mr. A. R. Bennett has been elected a vice-chairman of the Executive Council of the Exhibition.

Wanted, a Word.—Viscount Bury, in a letter to the *Times*, asks for a word which shall express progression by electric power corresponding to the words steaming, sailing, used in connection with ships, &c. Three conditions are, he says, essential; the word must be short—monosyllabic if possible—must have some immediate relation to electricity, and should, as far as may be, explain itself. He suggests accordingly the expressions "to ohm" or "to volt." For instance: "An electric launch takes about half an hour 'to volt' from Mortlake to Putney;" or, again, "Sixty miles a day would be a fair day's ohming for a small launch." The new verb, "to electrick," invented by Mr. Geo. Offer was bad enough in all conscience; but Viscount Bury has outdone all competitors in the race for eccentricity. Let us hope that this will be the last of his contributions to electrical literature, although his suggestions have been followed by others nearly as bad; *vide* the *Times* of yesterday.

A Fact.—After twelve months at high tension the shareholders of the London Electric Supply Corporation have been informed by their engineer that their system is wrong in the main.

Extremes Meet.—While the quack doctors are proclaiming that electricity is life, the State of New York has decided that electricity is death.

The Royal Military Exhibition.—The electric lighting of these buildings has been entrusted to Messrs. Davey, Paxman & Co., of Colchester.

Private Companies and Corporations.—The *Financial News* says: "We understand that the representatives of the electric lighting companies are fully alive to the importance of counteracting the steps recently taken by the Association of Municipal Corporations in regard to the retention of the transfer clause in provisional orders applied for by local authorities. The committee of the electric supply companies are likely to take the matter in hand, and we should anticipate that the London Chamber of Commerce will give them their cordial support. The question involved is of far greater importance than might at first sight appear. The value or convenience of the clause to the corporations is quite appreciated by municipal authorities. Hence their eagerness to retain it. In the absence of strong representations as to the objectionable character of the clause, the Board of Trade might, perhaps, be induced to yield to the persuasions of the local authorities—a result which, as we have already pointed out, would be most unfortunate for the electric lighting industry."

A Relic of Volta.—*Elettricita* publishes an interesting document under the hand of the celebrated Volta, of which the following is a translation. Our contemporary does not state the occasion upon which the declaration was made, but produces it ironically as evidence of State munificence towards scientists:—"The undersigned declares upon my solemn oath that I receive no pay or pension from the State other than that which I have as a member of the Institute of Arts and Sciences."

Brighton Electric Lighting Works.—The time for sending in tenders for the several sections of the Brighton Corporation Electric Lighting Works has been extended to the 16th inst., at 11 a.m.

National Telephone Electrical Society.—The last two meetings held on the 21st and 28th ulto., were exceptionally interesting; at the former Mr. A. H. Church read a paper on "Telephony Abroad," in which he dealt at some length with the Van Rysselberghe system of telephony, telegraphy, and also with duplex telephony. On the 28th Mr. W. A. Baxter read a paper entitled "Inspection of Telephone Instruments."

The Uses of Electricity.—Electricity, according to a French contemporary, relieved the Oxford and Cambridge Boat-race this year of its usual monotony. The efforts of the competitors were, it seems, assisted by the presence of an electric yacht, *La Vicomptesse Burry*, the accumulators of which were similar to those used by Messrs. Immick & Co. for their station at Mortsake (*sic*). She had on board a "compagnie select," composed of the *haute aristocratie*, the guests of the "Compte and Vicomptesse Burry."

The Longevity of Underground Conductors.—It seems that the last paragraph of the article on "Underground Lines," which we publish this week, might be taken advantage of by electric light companies. The Metropolitan Electric Supply Company already places its leads in iron piping, and we may also add that the whole of the underground work of the Postal Telegraph Department is laid in the same manner.

Social Gathering of Yorkshire Telephonists.—On Friday evening, March 21st, the staffs of the various centres in the Yorkshire district of the National Telephone Company, Limited, assembled to spend a social evening at St. James's Hall, Leeds. The gathering was presided over by Mr. J. C. Chambers, in the absence of Mr. J. A. Chambers, district manager. Mr. Chambers was supported by the managers for Leeds, Dewsbury, and York centres. After the tables had been cleared, Mr. A. Greenwood, a member of the Bradford staff, proposed the toast, "Success to the National Telephone Company, Limited," which was responded to by Mr. J. C. Chambers. "The Health of the Managers" was given by Mr. Geo. Hey, a member of the Leeds staff; Mr. W. G. Gray and Mr. A. Drummond, managers for Dewsbury and Leeds respectively, replying. The evening was very enjoyably spent, and the opportunity of social intercourse with the members of the various staffs in the district fully appreciated. About 140 persons were present. Previous to the gathering (and at the Leeds offices) a gold watch was presented to Mr. J. C. Chambers, late general manager for the Yorkshire district, by Mr. James Holroyd, of Halifax, on behalf of the united staffs, as a token of the high esteem in which he was held by them during the many years of his connection with this district. Mr. Chambers has recently removed into the Lancashire district.

The Sardinia Street Station.—Rumours have recently been afloat, as we mentioned a fortnight ago, that several mishaps had occurred within a few weeks in this station. We are assured by the engineers that, although one or two momentary extinctions of the lamps on some circuits had occurred, these were due to causes which are not likely to be repeated, and that nothing approaching a break-down has happened, although the plant runs night and day. We are always glad to do everything that is possible to relieve the public mind of any anxiety on the score of the reliability of electric lighting, and we take this opportunity of stating that, after a personal inspection of the station, it is not easy to see how any serious hitch in the supply is likely to occur. Engines and dynamos are in duplicate, and can be instantaneously changed if necessary, and the conductors have never yet given any cause for complaint. When we say that they are of the best Silvertown manufacture, and that the pressure does not exceed 1,000 volts, consumers may rest pretty well assured that so long as the company does not endeavour to supply more lights than the capacity of the plant will allow, there is but little fear of failure.

The Phonograph and Graphophone.—Arrangements have been made with Mr. Edison by which a new company is being formed to control both these machines in all countries outside the United States and Canada. The company will have possession of all machines and instruments under the patents, and the capital backing the syndicate is unlimited.

Electric Trams, New York City.—Another cross-town street railroad company has been incorporated in New York City, with capital stock amounting to 500,000 dollars. The length of the road with branches will be about 7¾ miles, and will be operated by electricity.

Society of Arts.—On May 14th, the following paper will be read:—"Prof. Elihu Thomson's Electro-Magnetic Induction Experiments," by Dr. J. A. Fleming.

The New Westinghouse Arc System.—It has been known for a considerable time that the Westinghouse Company has been elaborating a new system of low tension arc lighting, and quite recently it has been advertised extensively, and put into practical use on something rather more than an experimental scale. The principle of the arrangement is rather a departure in the way of arc lighting. A series of transformers is distributed along the line of the primary circuit, and the arc lamps are operated from the secondary coils of these transformers. The series transformer is especially adapted to working an arc system in very much the same way that transformers in parallel are so admirably suited to the needs of incandescent lighting. The conditions of series transformers, says a New York exchange, are very favourable to steadiness of light from the fact that a large change in the resistance of the secondary circuit produces relatively but a small change in the current and electromotive force of the secondary, consequently small variations in the resistance of the arc, and small irregularities of feed, will produce a comparatively slight effect upon the energy supplied to the lamp. This greatly tends to steadiness and regularity of the light. Inasmuch as each arc lamp is operated from the secondary coil of a transformer, the dangerous feature of the arc circuit is in a great measure removed, since unless the primary current should break through into the secondary, no more than 50 volts electromotive force is at any time in the lamp circuit, consequently an arc lamp operated on this system can (except for the danger of burning one's fingers and the possibility of a breakdown in the insulation of the transformer) be handled as safely as an ordinary incandescent lamp, and as the transformers can be, and are, placed outside the buildings they supply, there is no necessity for a high-tension current ever entering the walls of the building. It should further be noted that not only does the alternating arc system possess these advantages, but it should be a very efficient method of distribution, for, as is well known, the modern transformer is exceedingly efficient when operated at its full load, and inasmuch as these series transformers are so operated, being from the nature of things free from the variations in load which can and do injure the efficiency of transformers in a parallel system of distribution, the loss in the transformation should be very small. In fact, it ought not to exceed five or six per cent., although no authoritative figures concerning these arc transformers have as yet been made public. The system is theoretically most interesting, and its operation in practice seems to be such as gives great promise for its future as a method of arc lighting. The results of the method are said to be remarkably satisfactory, and its details will certainly be of great interest.

A Correction.—In the article "A Synthetic Study of Dynamo Machines," in our last week's issue, second line from the bottom of right hand column, page 375, for "number of belt" read *belt of conductors*.

The Deptford Central Station.—The *Mechanical World* says:—"Mr. Ferranti is very sanguine as to the ultimate success of his system; but it must be remembered that the whole undertaking is a gigantic experiment. The station will either be a great success or a great failure; but at present it would be very difficult to predict which of the two it will be, as time only will show." Our contemporary might have added that the time is not far distant.

Electricity in Mines.—Messrs. Mallard and Le Chatelier have made a study of electricity in its application to mining, from which they draw the following conclusions:—Portable electric lamps (permanent electric lighting being out of the question as impossible) cannot be substituted for the "safety" ones in present use; and as regards the employment of electricity at high tension in the transmission of power, they consider it to be much more manageable and economical than compressed air, although open to the charge of adding another danger to those which unfortunately are inseparable from mining operations.

Presentation.—On Wednesday last Colonel Jackson presented to Mr. W. B. Campbell a handsome gold watch, bearing the following inscription:—"A present from the Directors and Officers of the National Telephone Company, Limited, to Wm. B. Campbell, Esq., on his retiring from the Secretaryship of the Company." Colonel Jackson expressed his great regret and that of his co-directors and the officers of the company at the loss of Mr. Campbell as a colleague, though such regret was tempered by the knowledge that the change was one of advancement to Mr. Campbell. We are sure that the regret so expressed will be echoed by all whose business has brought them into contact with Mr. Campbell during the many years in which he has been connected with the telephone interest.

NEW COMPANIES REGISTERED.

Andrews and Preece, Limited.—Capital £25,000 in £10 shares, 200 of which are deferred shares, to be issued to the vendors as part of the purchase consideration. Object: To take over the business of electrical engineers, carried on by Messrs. Reginald Andrews and Thomas Preece, at Bradford. Signatories (with 1 share each), Thomas R. Andrews, Thomas Preece, R. C. Douglas, electrical engineer, and James Duff, all of Bradford; A. Hanson, Appleby, electrician; J. H. Murgatroyd, Halifax; William Booth Brayshaw, Manningham. Registered Office, Borough Mills, Manchester Road, Bradford. Registered 1st inst., without articles of Association, by Messrs. Waterlow Brothers and Layton, Birchin Lane, E.C.

Tilbury Portland Cement Company, Limited.—Capital £25,000, in £5 shares. Objects: To purchase the patent rights of Mr. David Wilson, of Millwood House, Grays, Essex, cement manufacturer, for the manufacture of concrete and metal telegraph poles, signal and other posts, insulators, &c. Signatories (with 1 share each): *D. Wallet, 15, Billiter Street; *P. Grey, 76, West India Road, E.; *D. King, jun., 14, St. Mary Axe; D. Wilson, Grays, Essex; John Smith, 105, Leadenhall Street; G. Haselgrove, 54, Comerford Road, Brockley; W. J. Smith, Hainhault Road, Leytonstone. The first three signatories are appointed directors; qualification, £500 in shares or stock; remuneration, £550 per annum, divisible. Registered 2nd inst. by Cattarns, Jelfs & Co., 33, Mark Lane, and upon these no call has been made.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Sunderland and District Electricity Supply Company.—The first return of this company is made up to the 3rd February. The nominal capital is £100,000 in £5 shares. The only shares at present taken up are the seven subscribed for by the signatories to the memorandum and articles of association.

Lange and Company, Limited (electricians).—The statutory return of this company, made up to the 3rd inst., was filed on the same day. The nominal capital

is £10,000 in £50 shares. Seven shares are taken up, and upon these £12 10s. per share has been called. The calls paid amount to £50, and unpaid to £37 10s. Registered office, 23, Billiter Street, E.C.

Taylor and Challen, Limited (civil, electrical and general engineers).—The statutory return of this company, made up to the 20th ult., was filed on the 24th ult. The nominal capital is £40,000 in £10 shares; 2,434 shares are taken up, and £7 10s. per share has been called thereon. The calls paid amount to £18,255. Registered office, Derwent Foundry, Constitution Hill, Birmingham.

Halifax Mutual Electric Light and Power Company, Limited.—The first return of this company is made up to the 13th January, 1890. The nominal capital is £20,000 in £5 shares; 1,106 shares are taken up, 105 of which are considered fully paid. Upon 1,101 shares £1 10s. per share has been called. The calls paid amount to £1,121 10s., and unpaid to £380. Registered office, at the offices of Blakey, Emmott & Co., Limited, Square Road, Halifax.

CITY NOTES, REPORTS, MEETINGS, &c.

Brighton Electric Lighting Company.

THE report of the directors of the Brighton and Hove Electric Light Company, Limited, for the year ending December 31st last, has just been issued. It says: The capital account has, during this period, been augmented by the sum of £3,860, which has enabled the company to increase the capacity and efficiency of its plant, and to rearrange and insulate the greater part of the overhead circuit in accordance with the new regulations of the Board of Trade. The profit and loss account, after writing off an ample sum for depreciation of plant (which has, however, been kept in thorough repair out of revenue), shows a balance of profit for the year of £529 10s. 10d., which, with the balance brought forward from last year's accounts, makes the sum to the credit of profit and loss account £557 19s. 8d., but in view of the law suit of "Garman *v.* the Company," the directors recommend that no dividend be declared in respect of the profits of the past year. It will be noticed that there is a falling off in the profits, which is due to three causes:—

(*a*) The loss incurred owing to the reduction of price from 1s. to 10d. per unit.

(*b*) The heavy extra cost of running the machinery night and day during the first half year.

(*c*) The great advance in the price of coal, ammounting to 7s. per ton.

The directors confidently look forward in the coming year to the business of the company at least yielding the former 5 per cent. dividend. The directors greatly regret that in consequence of the opposition of the Corporation of Brighton and of the Hove Commissioners, they have been disappointed in their efforts to obtain a provisional order under the Electric Lighting Acts, 1882 and 1888. They trust, however, that the Corporation's sense of honour will soon modify this opposition, and that this company, which is quite willing to submit to any fair terms to be imposed by the Town Council, will not be subjected (after building up a business during the past seven years) to what would practically amount to an act of confiscation and ruin of a local business. Application is, however, being again made this session, and the company are confident of eventually either obtaining a provisional order, or coming to satisfactory terms with the Corporation. In the event of a provisional order being obtained, a large extension of capital will be necessary, and private friends of the company have expressed their willingness to subscribe the same. During the past year, Mr. Arthur Wright has resigned his position as managing director, and Mr. Albert Gay has been appointed in his stead to manage the works. The retiring directors are Mr. Robert Hammond and Mr. P. A. Latham, who offer themselves for re-election.

The Bedford Electric Lighting Company.

THIS company held the first annual general meeting at Bedford last week; Sir Henry Mance presided.

The Chairman said: The company was formed in August, 1888, and this was practically the statutory meeting. They proposed to start in a small way, increasing it afterwards if they found it necessary, and they approached the Corporation with the object of obtaining permission, because they felt it would be useless to start a company if the Corporation was in any way hostile to the movement. The company offered very liberal terms: that the Corporation might have the option of purchasing at cost price or a little over every five years, and he did not know that any more liberal terms had been offered to any Corporation by any company in England. The Corporation could not make up their minds to give the permission, and commenced a series of investigations with the object of determining whether they could not do the work themselves. They had necessarily to wait another year, as the time had passed then for giving notice of their intention to apply for a provisional order; but when the time came round last year they gave notice of their intention to apply. With regard to the opposing company in the field—the House-to-House Company—he had looked up the records at Somerset House, but found nothing to lead him to suppose that any serious opposition would be offered in that quarter; but knowing there was the possibility of other companies coming forward, they thought it best to put themselves *en evidence*, and issued a prospectus to assure the Corporation they were really in earnest. All they could do now was to await events. Meanwhile, they were not spending any money, and they would take care not to spend any until they were sure they could do it with advantage to the shareholders. If the Corporation made up their minds to do the work themselves, their occupation, so far as Bedford is concerned, would be gone. But if he might express his personal opinion he would say the Corporation would act very wisely if they gave it to a company, and if they did so he submitted that the local company had a greater claim to have the concern than any outside company that had recently come into the field.

On the proposition of the Chairman, Mr. Ald. Haynes, the retiring director in rotation, was re-elected, and this concluded the business.

Exeter Electric Light Company.

A MEETING was held on Monday week at the company's works for the purpose of confirming the following resolution unanimously passed at a meeting held on the 11th ult.:—"The number of directors shall be ten, or such smaller number (not less than five) as the directors may from time to time determine." Mr. W. Horton Ellis presided, and there were also present Dr. Woodgates, Messrs. H. S. Massingham (managing director), C. J. B. Sanders, Knill, L. J. Kennaway, J. J. Darke, and H. W. Mitchelmore (secretary).

The Chairman moved the confirmation of the resolution.

Dr. Woodgates, in seconding, said there was still a great deal of opposition to the electric light, although in London it was found in nearly every club, restaurant, and hotel, while the P. and O., Australian, American, and West Indian liners, as well as many of the railway trains, were lighted by electricity, because it was a better and safer light than gas. In Exeter three silversmiths' shops had the electric light, and the managers said that it was simply perfect, as it was not only a great comfort, but did not tarnish the goods as gas did. The opponents of the light said it was unsafe, but he would ask anyone whether it was as dangerous as gas. It was the steadiest and healthiest light in existence when the wires were properly insulated. It had also been said that there had been failures at the theatre, but it should be remembered that it was started with new machinery, which ought to have been kept experimentally running two or three weeks. Exeter, it was said, was a little behind, and town councillors had said that they must wait until the electric light was more developed, probably unaware of the fact that Madrid would be lighted by electricity before the end of the summer. If the light worked well elsewhere, there was no reason why it should not in Exeter.

Mr. Massingham said he had received a communication to the effect that ten members of the Honourable Commissioners of Sewers, with their clerk and engineer, intend next week to visit Bath, Taunton and Exeter for the purpose of seeing the works in each of these West of England towns, and examining all the electrical arrangements. These were the only three towns in the United Kingdom which the deputation would visit, and he thought the people of Exeter ought to regard this as a very great compliment. He gathered from the communication that the Commissioners had been advised that the installations in the West of England were the most advanced, and it should be gratifying to them to know that the greatest city in the world would come to them for the purpose indicated. He regretted, however, that Exeter was not publicly lighted by electricity like Bath and Taunton.

The Chairman agreed that it was a great pity that the city was not lighted by electricity. Many buildings, however, had the light, in addition to twenty-two shops and private houses, and they had a great deal of work in hand, the Museum being among the places which they were about to light. He looked forward to the good sense of the citizens generally coming to their rescue, and enabling them to carry out a first-rate installation in Exeter.

The motion was carried, and on the motion of the Chairman, seconded by Mr. Knill, Dr. Woodgates and Mr. J. J. Darke were elected directors.

Elmore's Copper Depositing Company, Limited.—The directors notify a dividend of 50 per cent., payable one-half on April 18th, and one-half as soon after June 30th as the accounts can be made up.

The Oriental Telephone Company, Limited.—The board propose a distribution for the year ended December 31st last of 3 per cent., and the transfer of £2,000 to the reserve fund, carrying forward a balance of about £1,200.

The Postal Telegraph and Cable Company.—It has been decided to increase the capital stock from £1,000,000 to £2,000,000, in order to pay Mr. J. W. Mackay for properties owned by him and worked by the company.

SHARE LIST OF ELECTRICAL COMPANIES.

Stock or Share.	Name.	Paid.	Closing Quotation. (April 3).	Closing Quotation. (April 10.)	Business done during week ending April 10, 1890	
					Highest.	Lowest.
100	African Direct Telegraph, Ltd., 4 p. c. Deb. Regd. and to Bearer	100	98 —101	98 —101		
Stock	Anglo-American Telegraph, Limited	100	49 — 50	49 — 50		
Stock	Do. do. 6 p. c. Preferred	100	83½— 84½	83½— 84½	84¼	83¾
Stock	Do. do. Deferred	100	14 — 14½	14 — 14½		
5	Australasian Electric Light, &c., Limited, Nos. 1 to 24,000 ...	5	... ...	... ...		
10	Brazilian Submarine Telegraph, Limited	10	12¼— 12⅜	12¼— 12⅜	12⅜	12 7/16
100	Do. do. 5 p. c. Bonds...	100	100 —102	100 —102		
100	Do. do. 5 p. c. 2nd Series, repayable June, 1996	100	104 —107	104 —107		
3	Brush Electric Engineering Ordinary, Nos. 1 to 63,416... ...	3	2¼— 2½	2¼— 2½		
2	Do. do. Preference, Nos. 1 to 63,416 ...	2	1⅝— 1⅞	1⅝— 1⅞		
14/-	Consolidated Telephone Construction and Maintenance, Ltd. ...	14/-	9/16— 11/16	½— ⅝		
Stock	Crompton & Co., Limited, 7 p. c. Pref. Shares, Nos. 1 to 20,000	5	5¼— 5⅝	5¼— 5⅝		
10	Cuba Telegraph, Limited	10	11 — 11½	11 — 11½	11	...
10	Do. do. 10 p. c. Preference	10	17½— 18½	17½— 18½		
5	Direct Spanish Telegraph, Limited...	4	4 — 4½	3⅞— 4⅛		
5	Do. do. 10 p. c. Preference	5	9 — 10	9 — 10		
20	Direct United States Cable, Limited, 1877	20	10 — 10⅜	10⅛— 10⅜		
10	Eastern Telegraph, Limited, Nos. 1 to 400,000	10	14 — 14¼	14 — 14¼	14¼	14⅛
10	Do. 6 p. c. Preference	10	14¾— 15¼	14¾— 15¼	15¼	...
100	Do. 5 p. c. Debs. (1877 issue), repay. Aug., 1899	100	106 —109	106 —109	108½	108⅜
Stock	Do. 4 p. c. Mortgage Debenture Stock	100	106 —108	107 —109		
10	Eastern Extension, Australasia and China Telegraph, Limited	10	14⅛— 14⅜	14⅛— 14⅜	14⅜	14¼
100	Do. 6 p. c. Debentures, repay. February, 1891	100	100 —102	100 —102	100¼	...
100	Do. 5 p. c. (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. ...	100	102 —105	102 —105		
100	Do. 5 p. c. Debentures, 1890, redeem. ann. drawings ...	100	100 —102	100 —102		
100	Eastern and South African Tel., Ltd., 5 p. c. Mort. Deb., 1900...	100	101 —104	101 —104		
5	*Electricity Supply Co. of Spain, Nos. 101 to 20,000	5	4⅜— 5¼	4⅜— 5¼		
2	Elmore's Patent Copper Depositing, Ltd., Nos. 23,001 to 70,000	2	4½— 5½	5½— 6	6⅛	5 5/16
5	Fowler-Waring Cables, Nos. 301 to 20,000...	3	2¼— 2⅝	2¼— 2⅝		
10	Globe Telegraph and Trust, Limited	10	8⅜— 8⅝	8⅜— 8⅝	8⅞	8 11/16
10	Do. do. 6 p. c. Preference	10	14⅜— 14⅝	14⅜— 14⅝	14⅞	14⅜
10	Great Northern Tel. Company of Copenhagen	10	15¼— 16	15¼— 16		
100	Do. do. 5 p. c. Debs. (issue of 1881) ...	100	100 —103	100 —103		
100	Do. do. do. (issue of 1883) ...	100	100 —107	104 —107	107	105½
10	Greenwood and Batley, Ltd., Ordinary, Nos. 4,667 to 14,000 ...	10	12 — 13	12 — 13		
10	Do. 7 p. c. Cumulative Preference, Nos. 2,667 to 8,000	10	11 — 12	11 — 12		
10	India-Rubber, Gutta-Percha and Telegraph Works, Limited ...	10	17½— 18½	17½— 18½	18¼	18
100	Do. do. 4½ p. c. Deb., 1896...	100	102 —104	102 —104		
25	Indo-European Telegraph, Limited...	25	41 — 43	41 — 43		
10	London Platino-Brazilian Telegraph, Limited	10	6 — 7	6 — 7		
100	Do. do. do. 6 p. c. Debentures ...	100	106 —109	106 —109		
10	*Metropolitan Electric Supply, Limited, Nos. 6,101 to 50,000 ...	6	5½— 6	5½— 6		
5	National Telephone, Limited, Nos. 1 to 386,875	5	5 — 5¼	5 — 5¼	5¼	5⅛
5	Do. do. New Nos. 386,876 to 436,700 ...	4	3¾— 4¼	3¾— 4¼		
10	Do. do. 6 p. c. Cum. 1st Preference ...	10	12 — 12½	12 — 12½	12 5/16	...
10	Do. do. 6 p. c. Cum. 2nd Preference ...	8	9½— 10½	9½— 10½		
1	Oriental Telephone, Limited, Nos. 80,001 to 300,000	11/-	5/16— 7/16	¼— ⅜		
8	Reuter's, Limited	8	7 — 7½	7 — 7¾	7⅞	...
1	South of England Telephone, Ltd., Ordinary, Nos. 1 to 2,000, 2,501 to 3,500, 93,251 to 300,000	1	¼— ⅜	¼— ⅜		
5	Do. do. 6 p. c. Cum. Preference, Nos. 1 to 20,000...	3½	3½— 3⅝	3½— 3⅝		
Cert.	Submarine Cables Trust	100	112 —117	112 —117	115	...
5	Swan United Electric Light, Limited	3½	4½— 5	... ...		
12	Telegraph Construction and Maintenance, Limited	12	43 — 45	44 — 46		
100	Do. do. do. 5 p. c. Bonds, red. 1894	100	101 — 104	101 —104		
5	United River Plate Telephone, Limited	5	4½— 5	4½— 5		
Stock	Do. do. 5 p. c. Debenture Stock... ...	100	90 — 94	90 — 94	92	...
100	Do. do. 7 p. c. Debs., Nos. 1 to 1,000 ...	100	... ...	... ...		
10	West African Telegraph, Limited, Nos. 7,501 to 23,109	10	9½— 10½	9½— 10½		
100	Do. do. do. 5 p. c. Debentures	100	98 —101	98 —101		
10	West Coast of America Telegraph, Limited	10	10 — 10½	9½— 10½	10	9¾
100	Do. do. do. 8 p. c. Debs, repay. 1902 ...	100	121 —126	121 —126		
15	Western and Brazilian Telegraph, Limited	15	10¾— 11¼	10¾— 11¼	11 3/16	11
7½	Do. do. do. 5 p. c. Cum. Preferred	7½	6⅛— 6⅜	6⅛— 6⅜	6⅛	...
7½	Do. do. do. 5 p. c. Deferred	7½	4¼— 4⅜	4¼— 4⅜	4 9/16	4⅛
100	Do. do. do. 6 p. c. Debentures "A," 1910...	100	103 —107	106 —109	103½	...
100	Do. 6 p. c. Mort. Debs., series "B" of '80, red. Feb., 1910	100	103 —106	103 —106		
10	West India and Panama Telegraph, Limited	10	3⅛— 3⅜	3⅛— 3⅜	3⅜	3¼
10	Do. do. do. 6 p. c. 1st Preference ...	10	11½— 12	11½— 12	11⅝	...
10	Do. do. do. 6 p. c. 2nd Preference ...	10	14½— 15½	14 — 15		
$1,000	Western Union of U.S. Tel., 7 p. c. 1st Mort (Building) Bonds	$1,000	122 —126	122 —126		
100	Do. do. 6 p. c. Sterling Bonds	100	99 —101	99 —101		
5	*Westminster Elec. Supply Corp., Ltd., Ord., Nos. 101 to 42,953	2	1¾— 2¼	1¾— 2¼		

* Subject to Founders Shares.

TRAFFIC RECEIPTS.

The Brazilian Submarine Telegraph Company, Limited. The receipts for the week ending April 4th, 1890, amounted to £4,134.

The Cuba Submarine Telegraph Company. The receipts for the month of March show a decrease of £540 as compared with the corresponding period.

The Direct Spanish Telegraph Company, Limited. The estimated receipts for the month of March were £2,328, against £2,129 in the corresponding period of last year.

The Eastern Extension, Australasia and China Telegraph Company, Limited. The receipts for the month of March, 1890, amounted to £41,133, as against £42,896 in the corresponding month of 1889

The Eastern Telegraph Company, Limited. The receipts for the month of March, 1890, amounted to £58,471 against £55,987 in the corresponding month of last year.

The Great Northern Telegraph Company, Limited. The receipts for the month of March amounted to £20,800.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending April 4th, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,172.

The West Coast of America Telegraph Company, Limited. The gross earnings for the month of March, 1890, were £4,490.

The West India and Panama Telegraph Company. The receipts for the half-month ended March 31st, show an increase of £27 as compared with the corresponding period.

ELECTRIC RAILROADS.

Dr. LOUIS BELL read a paper before the Chicago Electric Club last month dealing with the application of "Electric Motors for General Railroad Work." The author introduced his subject by the statement that the electric motor for street car service is an accomplished fact, as some hundreds of miles of road in daily operation bear witness. Regarding the possibility of handling trains, two questions arise. First, can we readily build a motor to handle railroad trains at railroad speed? Second, can we rely on a motor with anywhere near the same feeling of certainty as on a locomotive? Both questions are answered in the affirmative. If we can build large dynamos capable of running continuously, there is no reason why we should not build equally powerful motors. A motor placed in a special motor car, and properly protected, ought to run as successfully as a stationary motor, and thus unless grossly overloaded, give little trouble. Dr. Bell gives a hypothetical case, a line 300 miles in length, and supposes it divided into 10 or 12 sections, each with a power station at its middle point. The potential at the motor terminals at the end of each section is taken at 1,500 volts, and the current transmitted 100 to 125 ampères over a line wire of No. 0 gauge, giving a calculated line efficiency of 85 per cent., the weight of copper per mile to be 3,600 lbs. The case where an electric system would work to the best advantage, is the elevated road. The damage to neighbouring property would be enormously lessened, and the present objections to an elevated system would be in a great measure removed. Dr. Bell goes deeply into figures as to the total efficiency of the electric system, the amount of coal burnt when compared with steam locomotives, the probable repairs and general costs of maintenance, and he comes to the conclusion that the reform cannot long be delayed; "it is only a question of who will be the first to display the necessary enterprise and energy, and give this city (Chicago) a system of rapid transit suited to its needs, and to the age in which we live. I would state my firm conviction that most of us will live to see electricity come into very extensive use in general railway work, certainly for special and suburban roads, possibly for long through lines." We cannot help admiring Dr. Bell's sanguine spirit, and we admit that his arguments are as reasonable as they are ingenious.

PHYSICAL FIELDS.

WE reproduce from *Science* the correspondence on this subject:—

It seems probable that the articles which have appeared in this journal *(Science)* on this subject—one by A. E. Dolbear,* on December 27th, and the other by N. W. Perry,* on January 24th—are the most important that have been recently written as bearing especially upon present theories in meteorology. It is of the utmost consequence that in this complex science we lay a sure foundation of fact, and never be tempted to speculations unless supported in the main by observations. It is not my purpose, even if I were able, to discuss the questions at issue in these papers, but I wish to present what seems to me may prove a most important field for research, hoping that others may take up the matter and shed light upon the problem.

The "thermal field" is probably the easiest to comprehend. We may conceive a white-hot cannon-ball in space. It radiates its heat equally in all directions, and is rapidly cooled. We may measure the distance to which these radiations extend. If these radiations be intercepted by any body, it in turn will be heated, and send back its radiations to the ball; and these exchanges will continue till a thermal equilibrium be established. All orthodox theories in meteorology regard the sun as a hot ball in space; that its rays impinge upon the earth, passing through the atmosphere without heating it; that this heated earth sets up convection currents in the atmosphere; and, finally, that all our winds and storms are primarily induced by these convection currents. I believe the time is not far distant when this theory will appear puerile in the extreme, and it will be acknowledged that the actions produced in any locality through the direct heat agency of the sun must be greatest just at the time when there are *no* storms, and all of them combined will not account for a hundredth part of the energy developed.

The "electric field" is the one I wish to specially notice. Mr. Perry, speaking of electrification, says, "It is a condition which is dual in its character. The negative exists because of the existence of the positive, not because of propagation from one to another. . . . We must regard electricity as motion: electrification, one kind of stress which is capable of producing electrical vibrations; magnetism may be another." Granting the existence of such a dual condition, without at present going into the question of how it can be energised or brought about, I wish to inquire what may be told or inferred as to the action of individual electrified particles in either the positive or negative portion of such a dual condition, let us say, in the atmosphere.

Take, for example, the electric arc. As I understand it, particles of carbon are continuously carried from what is called the positive pole to the negative, and the latter is built up at the expense of the former. I do not know that the velocity of these particles has even been estimated, but it must be exceedingly small as compared with that of electricity (186,000 miles per second). Suppose we have a positive and a negative electric field, or dual condition, in a dusty atmosphere: may we not say that the dust in the positive field, if sufficiently electrified, will have a tendency to pass toward the negative field? Or, if we consider that moisture particles take the place of dust, why may not these, positively electrified, have a tendency toward the negative field? We have an illustration on a large scale in the case of thunder-clouds which have been repeatedly seen to approach each other. Mr. Dolbear writes me that he has himself noted a most remarkable and sudden clearing of clouds after a thunderstorm. I have myself observed a line of blackness gradually advance in a clear sky, the line stretching from the south-east to the north-west. The demarcation between the clear sky and the black cloud was almost geometrical in its sharpness. No rain was felt till the edge of the cloud reached the zenith; and then rain fell in torrents, though there was blue sky almost directly overhead.

But there is a still more important consideration. The difficulty of changing the moisture contents of the air is universally recognised. The number of grains per cubic foot will remain absolutely constant for days at a time, no matter what may be the heat conditions of the earth, its winds, clouds, or any other changes in the meteorological elements. A sixteen-hours' steady rain has not been sufficient to saturate the air. Notwithstanding these facts, we now know that accompanying a storm, and independent of the sun's heat, there are most extraordinary fluctuations in the moisture contents of the air. Frequently, over an area of 160,000 square miles, this moisture may be doubled, and immediately following the storm it may be diminished three-quarters of this; and this, too, absolutely independent of the wind, pressure, or temperature. I will give but one illustration. On December 22nd, 1889, at 3.11 p.m., I observed 4·09 grains of moisture per cubic foot in the air, which was calm at the time. At 5.2 p.m., or 111 minutes later, there were only 1·04 grains per cubic foot. This was certainly the greatest diminution I ever observed, but several times I have observed it almost as great. Without going into the questions, which this discussion must raise, it seems to me that such extraordinary changes can be abundantly accounted for on the principles enunciated in this journal, and cannot be accounted for in any other way. What we need most of all are

* See ELECTRICAL REVIEW for January 24th and February 21st.

experimental determinations showing the possibility of such transfer in electric fields. Have we any help from the difficulty of running a Holtz machine in a damp room from the gathering of dust and lint on electrified glass rods? Is it possible to electrify a mass of air so as to test any of these questions? Thus far I have hoped only to interest others more familiar with the subject than myself. I do not expect that I have added anything to our knowledge; but, as Prof. Holden has said recently, regarding photographic magnitudes of stars, "any discussion of the question at this stage can but be advantageous," so it seems to me in this field of research we may well consider that any consideration of the questions involved must tend to bring out the best thoughts of many minds; and "in the multitude of councillors there is wisdom."

H. A. HAZEN.

Northfield, Minn., *January 28th.*

In my communication on physical fields, published in *Science* of December 27th, what I was most desirous of pointing out was the character of the physical reaction of a field of a given sort upon a body in it. The explanation of the various steps was unessential, entirely so; and, if my explanations were not the true explanations, the conclusions reached in the main thesis would not be vitiated.

Mr. N. W. Perry takes some exceptions to my terminology, which are proper enough if I have not used appropriate terms. I most heartily agree that in all departments of science the terms used should be explicit, definite, and not misleading; but it is unfortunate indeed that all through physics, to say nothing of other sciences, there is no general agreement as to the proper use of terms. Take, for instance, the term "heat." Some say "heat is vibratory atomic or molecular motion," others just as competent say "heat is a form of energy." Now, both cannot be right, unless a mode of motion is a form of energy. Again, note the long controversy lately had in England over the proper use of the words "mass" and "weight."

The significance of it is this: that, until there is a well-settled use of a word in a technical sense, one cannot altogether be blamed if he uses the word in a sense different from some other one. Now, Mr. Perry is certain that I do not use the word "stress" properly; that it "is not proper to say that a stress travels;" that Maxwell and others do not believe that electrification involves motion in any way; that potential conditions or energy are static, and that I have made a fundamental mistake in not discriminating between static and kinetic energy.

To all this I have to reply:—

1. Suppose an electrometer to be, say, one metre from a glass rod which I electrify with a piece of silk. If the electrometer gives any indication of electrification, the condition that incites it has travelled with a finite velocity. Whether it be called a stress, a strain, or anything else, is immaterial; whether it is a condition of the ether or action at a distance in the sense the older philosophers thought, does not matter so much if it takes time to go from the glass rod to the electrometer. One may call it potential or kinetic energy if he chooses; a static condition will presently be reached, but not instantly. And the same is true of the effect produced by magnetising a piece of iron.

Mr. Perry seems to say that, if there was but one body in the universe, it could not have an electric field, even if it could be electrified. If that be his meaning, I must say that his conception of electrical re-actions is totally different from mine. As Tait has it, "every action between two bodies is a stress." The body and the ether about it are two bodies; and, if they can act at all upon each other, there will then be a field. Perhaps, however, Mr. Perry calls the ether matter, which has not been my habit, and against which I was not on my guard when I wrote the statement to which he objects. Until we have some evidence that ether is subject to the law of gravitation it seems to me to be improper to speak of it as matter. If "every particle of matter attracts every other particle of matter," and if there is no evidence that ether is so attracted, it is not conducive to good terminology to call it matter.

2. This term "stress" has not been long in use at all, and the adoption of it into electrical science I suppose to be due chiefly to Maxwell. I have therefore looked to see how he employed it, and I find the following in his treatise on "Electricity and Magnetism," Art. 866:—

"Now, we are unable to conceive of propagation in time, except either as the flight of a material substance through space, or as *the propagation of a condition of motion or stress* in a medium already existing in space." The italics are mine, as I interpret them to mean precisely what I meant. Evidently Maxwell did conceive that stress could travel.

Again, in Art. 863 he says: "The emitted potential *flows* to the body;" and, once more, "The potential as received by the attracted body is identical with, or equal to, the potential that arrives at it;" and, once more, "The velocity of transmission of the potential is not like that of light, constant relative to the ether or to space, but rather like that of a projectile, constant relative to the velocity of the emitting particle at the the instant of emission."

These quotations seem to me to justify me in the use of the word "stress" as a condition capable of translation from one point to another. It is not unlikely, though, that within the past few years, and since Maxwell's death, the term has become more precise; and that, if true, would justify calling attention to a departure from such use.

A. E. DOLBEAR.

College Hill, Mass., *February 2nd.*

I think Prof. Dolbear misunderstands the motive of my communication relative to physical fields, that appeared in *Science*, January 24th. It was not so much what I conceived to be misuse of the term "stress," that I wished to call attention to, but rather what I believed to be a misconception of the nature of certain phenomena which such misuse seemed to imply. Let me see if I can maintain my ground.

If two bodies connected by an elastic medium retain their relative positions, the two may be transported or caused to move in any or all possible ways, and still with all speeds; yet the condition of stress under which this elastic connecting medium exists is not changed at all. If a force be exerted upon one of these bodies, tending to change its position relative to the other, the stress of the elastic connecting medium will be changed; and I do not think it necessary to conceive of a rate of propagation of this modified stress from the one object to the other; for, if the second body were not attached to the first in some way, the force applied to the first could produce no stress whatever in the medium connecting the two. A push on one becomes a pull on the other, but there could be no push on the one without there being an exactly equal and opposite effect upon the other. Has any propagation taken place in this case?

If, again, we have a system of bodies, all of which are connected with each other by elastic strings or by a pervading elastic medium, any movement of one of these bodies necessarily involves a change of stress between all of them. A push on one means a pull of exactly equal amount on others. There can be no push without a resistance, and this resistance is a quality of the elastic medium given to it by the mere presence of the other body. We have seen, in the case of the two bodies connected by an elastic string, that the stress is due to the relative positions of the two bodies. They were brought into their position by motion; but, so soon as this motion was overcome by the elastic resistance of the string, the force applied became potential, not kinetic.

Now, supposing one of these bodies to remain stationary while the other is moved farther away, the stress between the two is increased. The push on the one has increased the pull on the other, yet there has

been no motion of the latter. The only motion there was in the system was that imparted to the former; and the motion was away from the latter, not towards it. A new static condition has been induced upon both of them, but can it be said to have been propagated from one to the other? I do not think it can.

Now, these two bodies thus connected may be moved from one place to another, yet, so long as they maintain their same relative positions, the stress or tension of the elastic between them will not vary. So, if a form of stress between two bodies in space may be conceived to be entirely independent of the presence of any other bodies in space, a relative motion of these two bodies between themselves involves a change of stress without propagation; and, again, if these two be relatively still, they may move relatively to all other bodies without changing their stress or altering their static condition with regard to stress; yet in one sense (and I conceive in this sense alone) is the stress properly said to be propagated.

Prof. Dolbear says: "One may call it potential or kinetic energy if he chooses: a static condition will presently be reached, but not instantly."

Right here, I suppose, lies the gist of the whole thing. The point I wished to make was that Prof. Dolbear did not distinguish between the condition of the medium in the two states of motion and rest. A potential condition involves motion only in so far as motion was necessary to bring it into being. It may in one sense be considered as stored-up motion, as it is capable of giving out again an equivalent quantity of motion, but it is not motion itself. He implies, and I agree with him, that motion precedes the potential condition. Now, this motion, or energy, if you choose, may be of any known kind (not necessarily electrical, but may be); and when, by reason of the work done, we have produced a condition of matter of a certain kind—when all the work has been done—we have a condition that is called electrification.

What I have been contending for is that the magnetic field and the fields of electrification and gravity are those fields when they are established (before that, in the interval during which they are being established, the fields are kinetic, not potential); that in the case of electrification the movement necessary or involved in its establishment is not the electric field, but is the electric current which can be propagated, and the condition of stress produced by that motion is the electric field.

It is possible, however, that I have not fully understood him. Perhaps he means something like this: Imagine, for instance, a row of material points numbered from 1 to 10 spread out in a row, and connected by elastic thread. If 1 and 10 are stationary, and the intermediate numbers are strung along the string, the tension upon the string is uniform throughout its length. If, now, No. 1 be moved a little farther from No. 2 than orginally, the tension on the string between the two would be greater than before. This would cause a slight movement of No. 2; and so on to No. 10, which we have imagined stationary. Would it take *time* for the pull on No. 1 to become apparent on No. 10? It would with all material elastics, because of their viscosity and inertia; but, if we use as our elastic the luminiferous ether, I maintain that it would not, for one of the main features assigned to it is absolute and perfect elasticity. If No. 1 were pushed nearer to No. 2, the lessening tension would exist at No. 10 at the same instant, because another property of the ether is absolute incompressibility.

Taking this latter characteristic of the ether—incompressibility—if we had a long pole (say a thousand miles long), if we should cause one molecule of that pole to change its position, would not every other molecule, even those a thousand miles away, be caused to move also, and would there be any time lost in their responding? Or, to put it in another way, if we should premise that the farthermost molecule should not move, would it be possible in any way to move the nearer molecules? I contend that it would not, and that if one moved, all must move.

He says:—"Mr. Perry seems to say, that, if there was but one body in the universe, it could not have an electric field, even if it could be electrified." That is not my statement, nor is it my idea. My idea is, that in the case of static fields, under which head I would include electrification, magnetism, and gravity, two exactly equal and opposite conditions are inevitable. I cannot conceive of there being a push without there being a corresponding and equivalent pull, without the destruction of equilibrium; and, if the equilibrium be destroyed, we have motion which may be in any direction whatever. This is what I conceive to be the difference between the two kinds of fields. As before stated, I do not believe a pull can exist without a corresponding push and yet maintain equilibrium. If the one exceeds the other, there will be motion towards the greater—there will be more positive than negative electricity; there will be more north-seeking magnetism than south-seeking magnetism, or *vice versa*; and by the same token one may exist without the other. By the same course of reasoning, if a stress can be propagated (as I use the term "stress"), there is implied an existence of one form (the positive) before the existence of the other (the negative), as the element of time is involved. Faraday distinctly states that there cannot be an absolute charge of matter. I stated my belief that a stress could not exist unless there were two particles. I should also have added that there must be a connecting medium between those two particles. If this be so, then it is clear without reasoning that, if either one of the particles or the connecting medium be wanting, the conditions for stress are wanting, and it cannot exist. A material body having two points and a connecting medium between the two is therefore capable of either magnetism or electrification. If one of the points be wanting, and energy be applied to the other, this energy, instead of being stored up by the tension of the elastic medium, and producing stress as before—which would be capable of giving out again an equivalent amount of energy or motion, which stress might constitute electrification or magnetism—produces no stress, but motion at once, which may be heat, light, or the electric current, or give rise to these.

Again, if there were but a single body in space, its physical field would, I think, be confined within itself, and not radiate outward indefinitely. Let us imagine space to consist of an elastic jelly: then all particles of matter in space are connected with each other by elastic bonds. One particle cannot be moved from its position without setting up stresses in space between itself and all the other particles. But it is evident that the algebraic sum of all the stresses is zero. If the stress be wholly positive on one body or particle the stresses on all the other particles will be negative and exactly equal in amount, whether there be a million or only one other particle. If there be but one other particle or body, all of the negative stress—electricity, if you choose—will be upon it, or perhaps rather in the medium joining the two. Now, since the stress lies wholly between these two (they are in no way connected with any other particles, or, in other words, they are the only two particles in space), they may be moved in any way, providing their positions relatively to each other remain the same, without altering the stress of the surrounding medium. Since they do move, there is kinetic energy; but this movement does not alter their relations to other particles, because there are no other particles; hence no additional stresses are set up. Their movement does not convert the potential energy stored up between them into kinetic energy, although a movement of one relative to the other would do so; and the resulting kinetic energy would represent the difference between the initial and final potential states of the system.

He quotes Tait as saying, "Every action between two bodies is a stress," and says that "the body and the ether about it are two bodies, and, if they can act at all upon each other, there will then be a field." But you will recollect that he makes this statement in controversion of mine, that, if there were but "a single mathematical point in space, there could be no

stress." I said nothing at all about there being such a thing as ether in this con nection, though I see the necessity of including it, and also the force of his argument; but I do not think Tait meant to consider the ether as a body in the sense in which Professor Dolbear here uses it. As I understand it, Faraday, Maxwell, Thomson, and I assume Tait also, believe the dielectric to be the active agent, and the conductor the passive agent, in all the phenomena which we are considering. The dielectric, whatever it may be—the ether, if you will—is really the seat of the strains which terminate in the two bodies connected. I think Tait used the term in the sense that I have indicated.

"Perhaps, however, Mr. Perry calls the ether matter, which has not been my habit, and against which I was not on my guard when I wrote the statement to which he objects. Until we have some evidence that ether is subject to the law of gravitation, it seems to me to be improper to speak of it as matter. If every particle of matter attracts every other particle of matter, and if there is no evidence that ether is so attracted, it is not conducive to good terminology to call it matter."

Let us see what authority we have for considering ether as matter. I believe the weight of opinion is either that the ether is a form of matter or that matter is a form of ether. Sir William Thomson believes that matter is nothing but ether; that it is composed of it. We know this all-pervading medium as ether when it is unorganised. When it is organised into vortex rings, we have the atom and molecule, hence gross matter, as it is usually distinguished. I am of the opinion that Sir William Thomson's theory of matter is the most popular one at present. In 1838, M. Pouillet found that the heat-energy transmitted from the sun to the earth would, if none were absorbed by our atmosphere, raise 1·76 grams of water 1° C. in 1 minute on each square centimetre of the earth normally exposed to the rays of the sun. This is equivalent to 83·5 foot-pounds of energy per second. This figure Sir William Thomson used in determining the probable density of the ether.

Herschel estimated the stress (elasticity?) of the ether at 17×10^9 pounds per square inch. S. Tolver Preston estimates the probable inferior limit of the tension of the ether at 500 tons per square inch, which is much smaller than Herschel's estimate. Young remarks, "The luminiferous ether pervading all space is not only highly elastic, but absolutely solid." I do not understand the meaning attaching to "solid" here, but it is evidently an attribute of matter. Sir William Thomson, calculating upon the data above referred to, finds the weight of a cubic foot of ether to be $\frac{2}{3} \times 10^{-2}$ pounds. Bellini makes it $\frac{1}{2} \times 10^{-13}$ pounds. M. Herwitz, another investigator, arbitrarily assumes a cubic foot of ether to weigh 10^{-18} pounds.

De Volson Wood treats the ether as if it conformed to the kinetic theory of gases, which, with other assumptions, is equivalent to considering it as gaseous in its nature, and at once compels him to consider it as molecular. He says, "The electro-magnetic theory of light suggested by Maxwell (?), as well as the views of Newton, Thomson, Herschel, Preston, and others, are all in keeping with the molecular hypothesis."

Prof. Rood succeeded in producing a vacuum of $\frac{1}{39000000}$ of an atmosphere. Prof. De Volson Wood states, that, even at this great rarity of the atmosphere, the quantity of matter in a cubic foot of air "would be some 200 million million times the quantity in a cubic foot of ether," and says, that, admitting that the ether is subject to attraction according to the Newtonian law, and of compression according to the law of Mariotte, in order to make the density vary sensibly with the distance, the attraction of the central body must be something like a million times as great as that of the sun, or have a diameter a million times as large; but, there being no such known body, he concludes that the density and tension of the ether may be considered uniform throughout space; and he says that the weight of a given volume of it would vary as the force of gravity, and places the weight of a cubic foot of ether at the surface of the sun at 57×10^{-24} pounds, and estimates the pressure on a square foot of the sun of a column of infinite height at 13×10^{-14} pounds.

Thus we see, that, while no two of these investigators agree in their results, they all agree in ascribing to the ether all the properties of matter, including that of gravity, and I therefore think it no violation of the proprieties to speak of it as though it were matter.

In regard to the definition of the word "stress," Prof. Dolbear quotes Maxwell as follows: "Now, we are unable to conceive of propagation in time except either as the flight of a material substance through space or the propagation of a condition of motion or stress in a medium already existing in space," and says, "Evidently Maxwell did conceive that stress could travel." I freely admit that a "condition of stress" may travel, in the sense that a body between the particles of which there exists a stress may travel; and it seems to me that is what Maxwell means. If he meant what Prof. Dolbear thinks he does, why does he say a "condition of stress?" Why not simply "stress?"

I think Maxwell was probably the first to use the term "stress," but it was in relation to phenomena described by Faraday. In regard to this, Maxwell himself says (Vol. I., p. 153): "The distribution of stress considered in this chapter is precisely that to which Faraday was led in his investigation of induction through dielectrics." Further, he says, "This is an exact account of the conclusions to which we have been conducted by our mathematical investigation. At every point of the medium there is a state of stress such that there is tension along the lines of force, and pressure in all directions at right angles to these lines." "The expression 'electric tension' has been used in various senses by different writers. I shall always use it to denote the tension along the lines of force, which as we have seen, varies from point to point, and is always proportional to the square of the resultant force at the point." "The hypothesis that a state of stress of this kind exists in a fluid dielectric," &c. "The state of stress which we have been studying." "If the medium is not a perfect insulator, the state of constraint which we call electric polarisation is continually giving way. The medium yields to the electromotive force, the electric stress is relaxed, and the potential energy of the state of constraint is converted into heat." "In the phenomenon called the electric current, the constant passage of electricity through the medium tends to restore the state of polarisation as fast as the conductivity of the medium allows it to decay. Thus the external agency which maintains the current is always doing work in restoring the polarisation of the medium, which is continually becoming relaxed, and the potential energy of this polarisation is continually being transferred into heat."

I consider the above as perfectly in accord with my statements in your issue of January 24th.

On p. 257, § 642, he specifically defines "stress" as follows: "Hence the state of stress may be considered as compounded of (1) a pressure equal in all directions, (2) a tension along the line bisecting the angle between the directions of the magnetic force and the magnetic induction, (3) a couple tending to turn every element of the substance," &c. "The stress in this case is therefore a hydrostatic pressure, combined with a longitudinal tension along the lines of force," &c.

But Faraday was the first to conceive of these stresses, although I am not sure that he used this term. In his "Experimental Researches," 3,249, he says: "With the electric force we have both the static and dynamic state; . . . . still there are well-established electric conditions and effects which the words 'static,' 'dynamic,' and 'current' are generally employed to express. . . . . The lines of force of the static condition of electricity are present in all cases of induction. . . . . No condition of quality or polarity has as yet been discovered in the line of static electric force, nor has any relation of time been established in respect of it." "No relation of time to the lines of magnetic force has as yet been discovered" (*Ibid.*, 3,253).

Finally, on pp. 439 and 440 of "Experimental Researches" (Vol. III. edition of 1855), he gives in detail, too long for quotation here, his views of the different phenomena, which, it seems to me, fully support the position I have taken in this matter.

NELSON W. PERRY.

ELECTRIC LIGHTING AND TOWN AUTHORITIES.*

THE German *Building Times* (Bauzeitung), quoted by the *Journal für Gasbeleuchtung*, gives a series of articles by Herr J. Baumann, Munich, on the above subject, which are of more than ordinary value, and of which we briefly jot down the main heads.

The discussions at Frankfort, Leipzig, Halle, Madeburg, and elsewhere having been noted, the author proceeds to compare electric and gas lighting. One difference is that in gas supply the technical difficulties are much the same in small and large towns; in electric the problem has for small districts been solved, while for large it is still practically unsolved, and large districts going in for electric light take a step in the dark. As to the question whether it is advisable in the present state of things for the authorities in large towns to take up the electric light, he says that to answer it is not so simple a task as at first appears. The tendency is for local authorities to get into their hands all the means of collective life, such as water, drainage, tramways, telephones, and gas; private electric lighting belongs to this category, and it might be best for them to take up electric lighting without its going, in the first place, into the possession of private enterprise. There is another important difference between gas and electric lighting, too often neglected: gas answers the demands of open-air lighting and of within-door lighting. So does electricity; but the advantages of electricity—coolness, safety, purity of the air—disappear entirely in the former. But it is the former, the open-air lighting, which entails the greatest difficulty and expense, and weighs down the within-doors lighting; this does not occur with gas. Another difference is the ease of putting up independent small electric installations for houses, theatres, places of amusement, and so forth, as contrasted with gas. The question, therefore, becomes one of the possibility of fitting in the new light in such a way as, by earning a fair profit, to do justice, amid the existing relations, to that portion of the community which cannot avail itself of the new system. From this point of view the conclusion would appear adverse to large schemes of supply for all purposes, and favourable to the supply of electric light as a special light suitable to and remuneratively saleable in certain special districts. The risk is thus minimised, for small special districts can and do pay; and the technical difficulties are brought within manageable compass; and have by this time been ascertained and can be provided for. And such small districts had better be managed by the local authorities, who can systematise the electric wires along with all other underground systems, such as heating and compressed air pipes, and telephone and telegraph wires, and thus cheapen each system.

As to the question of alternate *versus* direct current: the author does not think the dispute is one about fundamentals; but it is still one of considerable importance in view of future development. We have to do with a machine house and an insulated network of wires: the latter consists of main trunks and supply branches, so far somewhat resembling a gas system; but the manufacture and the supply are, in gas, independent, while in electricity they are not, and the central station must keep going, while the consumption varies enormously from hour to hour, the conditions being, therefore, uneconomical. The two systems to be compared, as being those in use up to this, are low tension direct and high tension alternating currents. In the former the current goes directly to the lamps, in the latter the circuit is closed, and currents of less tension induced by it in transformers are used in the lamps.

The energy required is the same in both cases; in the former it is supplied at low tension and high in quantity; in the latter it is supplied at high tension and low in quantity; and as the loss on the way is proportional, first, to the resistance, and, secondly, to the *square* of the *quantity*, it follows that the low-quantity system—that is the high tension system—suffers less loss in transit, and can bear either thinner cables or a longer conducting cable, or both, and can therefore be worked with light cables at greater distances than the low tension system can; and it therefore renders possible the establishment of stations at a distance instead of close to the supply, and, accordingly, the supply of larger areas: and the advantage of cheapness of cables tells best when the areas to be covered are very large. Hence the system is advocated for town supply, and is most advantageous in that particular respect in which electric lighting is itself least, or not at all, so—namely, in street lighting. In the meantime, at the present stage of electrical progress, the alternate system presents advantages in respect of simple machinery, easier regulation of tension, and smaller cost per unit of electrical energy. Laying and maintaining mains are much the same in both systems; but it is more difficult in the high tension to insure and maintain due insulation. In both cases the wires must be laid underground; this imposes a heavier strain on the high tension canalisation, when it conveys energy to larger districts—a circumstance which goes far to neutralise the primary economy in copper: unless, indeed, a part of the system be laid overhead. The high tension wires have therefore to be laid in solidly-constructed beds, unless they can be accommodated in sewers, &c., as in Paris. The constancy of supply depends on the good condition of the greater length of high tension cable; and the high tension is dangerous to workmen looking for faults or effecting repairs, either in the cables or about the transformers. For glow lamps both systems are equally suitable; for arc lamps both use an equal amount of energy, but the alternating current affects the carbons so as to throw more light up, an effect which can only be partly obviated by reflectors; and the alternating current in an arc lamp is noisy and produces less agreeable colours.

The comparison has hitherto run between high tension alternating and low tension direct. What about high tension direct? There are no transformers for this as simple and efficient as those for alternating currents, which give a return of 90 per cent. But high tension direct currents might be advantageously used with accumulators, which would give off at lower tensions, and would keep up the supply in case of a breakdown, or so as to enable a more economical working of the engines in respect of time. Unfortunately the sub-station, where the accumulators are, must occupy a good deal of space; very attentive supervision is necessary, accumulators are so dear that the advantage of cheaper cable disappears; yet in every town there are circumstances under which the use of accumulators would present advantages. Perhaps these circumstances may not be sufficient in themselves to call for a huge direct current station, but would lend themselves well to a small district arrangement. Such circumstances are theatre and concert hall lighting, for which all known precautions are necessary, and the use of accumulators in which ought not to be limited to the mere supply of an emergency light; though, on the other hand, the friends of an alternate current urge that the run of an alternate station is as steady as that of a gasworks. Electro-plating, chemical laboratories, electro-chemical industries call for direct, not for alternating currents; and as to the use of current for motors, it may be said that while the conditions are variable, and are most favourable where small powers are used in an industrial town, it does not at present appear that

* *Gas World.*

there is a pressing call for electricity for motors, to be put in place of the existing arrangements. At present the advantages are fairly balanced; and the establishment of power buildings is outside the sphere of an electric supply station. Electricity for motors, then, can scarcely be one of the hopes of a local authority proposing to put up an electric station. At present there are no alternate current motors to compare with direct current motors in efficiency, price, or management.

As to the dangers to life, health, and property; the peculiarity of the individual has a great deal to do with the result; but alternate currents, even the small ones used by medical men, are physiologically far more powerful than constant currents; the high tension alternating current of a central station is in the highest degree dangerous to life, the constant current of a small district installation is safe. The numerous fatal accidents and permanent injuries caused by alternate currents in America are sufficient to show this; but their number is mainly due to overhead working, which, in the author's view, is wholly inadmissible; still there always remains danger in the machine house and at the transformers. With direct currents there is no such danger to the consumer; and with alternate there is also none, so long as all works well at the transformers; but let the supply wires and the house wires come somehow into communication; then the house wires are more dangerous than the mains themselves, because they have not been calculated to stand the new strain, or fitted up so as to do so; and the dwellers in the house are not experts in self-protection. So, also, if the insulation in the transformers breaks down; and Dubraoa has quite recently called attention to the high tension developed in the wire supplied by a transformer at the first switching on, if that wire have any considerable capacity, a tension which may quite easily result in a dangerous spark, and to which there is nothing analogous in direct current lighting. The danger of fire from direct heating of the wires is about the same in both systems.

As to electric tramways, there is no doubt that electricity will be much used for this purpose, whether from central stations or in accumulators carried in the vehicle. The use of the direct current is preferable in the former case, and alone possible in the latter, which seems to have the greater future.

The author's conclusions are:—(1) Local authorities should not try, electrically, to cover the whole ground; (2) they should introduce the electric light without delay; (3) in small districts by direct currents; (4) on public account.

NEW PATENTS—1890.

4125. "A new and improved electric bell." E. BERG. Dated March 17.

4189. "The ball socket switch for electric lighting." F. SUTER. Dated March 18.

4191. "Improvements in method and mechanism for generating heat, steam, and light by electricity." T. D. FARRALL. Dated March 18. (*Complete.*)

4220. "Improvements in switches for opening and closing electric circuits." H. C. L. HOLDEN. Dated March 18.

4231. "Improvements in the construction of arc lamps." W. E. GRAY. Dated March 18.

4232. "An improved construction of incandescent electric lamp." W. E. GRAY. Dated March 18.

4235. "Improvements relating to filaments for electric lamps for signalling and other purposes." J. P. REES. Dated March 18.

4242. "An improvement in electric railway signals." A. SIEMENS. Dated March 18.

4260. "Improvements in or appertaining to electrical distribution." W. P. THOMPSON. (Communicated by C. G. Young, United States.) Dated March 18.

4337. "Improvements in electrical, steam, or other power, or hand cranes, or other apparatus for raising and lowering." R. BOLTON. Dated March 20.

4350. "Improvements in apparatus for the closing and opening of electric circuits." H. T. BARNETT. Dated March 20.

4366. "Improvements in electrical thermometers or electrical instruments sensitised by heat for use in electrical meters and other electrical apparatus." T. H. PARKER. Dated March 20.

4383. "Improvements in the preparation of active or storage material for use in secondary batteries or accumulators." J. PITKIN and H. C. L. HOLDEN. Dated March 20.

4384. "Improvements in plates for secondary batteries or accumulators." J. PITKIN and H. C. L. HOLDEN. Dated March 20.

4405. "Improvements in armatures for dynamo-electric machines and motors." W. B. SAYERS. Dated March 20.

4407. "Improvements in electric railways." J. B. MCGREW. Dated March 21. (*Complete.*)

4533. "Improvements relating to safety devices for electric circuits." H. H. LAKE. (Communicated by the Thomson-Houston International Electric Co., United States.) Dated March 22. (*Complete.*)

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1889.

656. "An apparatus for measuring direct or alternating electric currents." W. H. DINES and L. W. GATWARD. Dated January 14. 6d. A small cistern kept filled with water or other liquid by a self-regulating valve. The liquid flows from the cistern through a suitable orifice and the rate at which it flows is regulated by the electric current in such a way that the flow is proportional to the strength of the current. 1 claim.

1038. "Improvements in and relating to electric lamps for signalling purposes." J. P. REES. Dated January 19. 8d. The main object of the invention is to provide a self-contained electric lamp by means of which flashes of light, of long or short duration, may be produced at the will of the operator for the transmission of signals or messages according to any pre-arranged system or code. One feature of the said invention is the combination with an incandescent electric lamp and an electric battery connected therewith, of a device for closing and interrupting the circuit of the said battery for the purpose of producing "flashing" signals. Another feature of the invention consists in making the lens or lenses adjustable towards and away from the light to suit the varying distances through which the signals have to be transmitted. 5 claims.

1420. "Improvements in secondary batteries." F. KING. Dated January 25. 8d. The inventor connects the whole of the plates of one denomination together, by means of the ordinary connecting bar at the top of the battery, and on the bottom corners of the said plates makes prolongations forming feet for raising the plates above the bottom of the containing cell, as described in specification dated the 10th December, 1887, No. 17,047, the said feet being metallically connected together by burning or casting thereto a metal strip which embraces the bottom edge of the whole of the feet of these plates. 4 claims.

CORRESPONDENCE.

Dynamo and Motor Design.

In your issue of the 4th inst., a letter appears under the above heading from Mr. W. B. Sayers, in which he complains that the "authorised abstract" of his remarks is "incomplete and misleading." Perhaps you will allow the writer of the abstract to express his great regret that cause for dissatisfaction should have arisen, and to add a few words of explanation.

First as regards "incompleteness." This I admit, for all abstracts are necessarily incomplete.

Next as to being "misleading," I am willing to admit that the abstract may not express exactly what he intended to convey, but I think Mr. Sayers has himself to blame for not having made his meaning sufficiently clear. This opinion is supported by the fact that he has found it necessary to rewrite his remarks before they are printed in the journal. He has also thought it desirable to add an "explanatory note" to his contribution, in which he puts his meaning much more clearly than it is given in the verbatim report of what he said.

In this note he also says "The explanation given by Mr. Swinburne in his reply to my remarks relatived only to the action which takes place *when the brushes are in the non-sparking position*, and agrees precisely with my statement of the case." This shows that even Mr. Swinburne had not properly understood the "true purport of what Mr. Sayers said," otherwise he would not have given as his own an explanation which Mr. Sayers had propounded a week previously.

Referring to Mr. Mordey's "correction," given on page 381 of your last issue, I would point out that no correction was necessary in that part of Mr. Mordey's

remarks, excepting, perhaps, that the word "partly" should be substituted for "probably" in line 13, page 363.

As to the action of the armature current in heating the pole-pieces, those who were present at the meeting will remember that Mr. Mordey confessed himself unable to recall the explanation of the action which he had intended to give. Hence that part of the so-called "correction" is really supplementary to his remarks, and formed no part of the discussion.

I take this opportunity of pointing out a printer's error on page 381, which occurs in the paragraph relating to Mr. Mordey's correction. The reference should be to page 363, not 383. I would also ask what is the meaning of the expression "from line 8 to the end?" Does Mr. Mordey mean that all his remarks after line 8 are to be deleted? If not, where is "the end" referred to?

The Writer of the Abstract.

["From line 8 to the end" was an expression of our own, and referred to Mr. Mordey's remarks which we printed on page 363, and which we could not correct at the time of publication. Mr. Mordey's own words to us were from "Brush machine to the end," and our correspondent will notice that the reference to this dynamo is in the eighth line.—EDS. ELEC. REV.]

Workmen's Grievance.

Knowing as I do that your paper is supported by a great many "linesmen" in the electric lighting business, I feel constrained to seek your indulgence for space to ventilate a growing evil committed by employers against workmen.

I am of opinion that the time has arrived when some employers ought to be put in the public pillory, and served in the same way as the "Rat House, or unfair wage-paying printing firms" were served recently.

It has come to my knowledge that a firm of reputed respectability, and who are shining lights of dignity and generosity, recently tendered for a job of over 150 lights, and were successful. My informant tells me the work had to be completed in three weeks, and the men had to work overtime, for which they were to be paid time and a quarter; this was paid the first week, but the second week, through the action of one of the officials, it was knocked off, and this mean act was sanctioned by the members of this eminent firm. Sir, can you conceive anything more mean and contemptible, in the face of the fact that this firm will, on the labour of the men alone, clear nearly *two hundred pounds* in the three or four weeks? just imagine their paltry action in robbing a man of 2½ hours per week! It sinks beneath contempt!

I have often heard it said that workmen are never satisfied; but this clearly shows that it is the avaricious and tyranical employers who are keeping up the conflict between "their capital, forsooth!!" and other men's labour, upon which they live.

I can appreciate your articles of practical and theoretical work, seeing how grossly incompetent some of these firms are, and with what impudence they deliberately take jobs and guarantee the completion of them in a certain (and often impossible) time; and yet never do anything towards it—in fact, perhaps never put a foot on the job—and if they did, and attempted to give any detail orders for work, they would only exhibit themselves as being absolutely useless.

This shows they force a burden on the workers which they themselves are incapable of bearing, though they can stand and grin while the worker is slaving, and, like legalised robbers, carry off the plunder—the proceeds of our labour.

I hope *linesmen* will remember this, and hope they will strive to make their electrical union strong enough to enforce all wiring being done by their unions—as the painters of America *do* in some parts—ridding themselves of the exploiter and being no longer robbed.

I trust you will grant me space for this rather long letter, and, believing in your desire to see fair play for working men in these critical times, I appeal to you for help to stop both the sweating and bad pay system which is being introduced; and also, if necessary, to give publicity to the names of the offending firms.

W. Spencer.

April 1st, 1890.

More Light on Electricity.

I have just completed experiments which prove that a surcharge of electricity on passing through the glass of a Leyden jar by conduction alters the attraction of cohesion of the glass, so that when the jar is fully surcharged the attraction of cohesion of the glass is then 550 times greater than it was before the surcharging commenced.

I also find that the specific increase of the attraction of cohesion caused by a surcharge of electricity varies according to the nature of the substance operated on, and hence there is now a door opened for our understanding the Peltier effect, and other electrical phenomenon, which have hitherto been inexplicable.

James Johnstone.

April 2nd, 1890.

The Physiological Effects of Currents.

Please allow me, for my colleague, Dr. Harries, and myself, to reply to the letter of Prof. Forbes, which you published last week.

That there is truth in the statement that the alternating currents from a dynamo differ from those produced by an induction coil, it would be folly to deny; but the extent of that difference, and its *effect upon the human body*, is another matter.

Unfortunately, for his case, Prof. Forbes proves too much. He writes:—"The instrument employed measures the *effective* current." . . . . "The discomfort measures the *maximum* value of the current;" and, further: "Thus the current which caused discomfort was probably 20 *to* 50 *times* the current measured."

If these statements be true, taking his lowest estimate of maximum current, and, therefore, according to him, of *discomfort*, the alternating current which in our experiments produced discomfort was $1{\cdot}7 \times 20 = 34$ *ma.* On the other hand, Prof. Forbes appears to accept our discomfort figure for continuous current, viz., 10 *ma.* But the Professor himself stated at the meeting that he *knew* he could not bear nearly as much alternating as continuous current, and several other speakers confirmed this.

As shown above, his letter proves that it takes *more than three times* as *much alternating current* as *continuous to cause discomfort.* In the days of Euclid this would have been called a *reductio ad absurdum*; but in the present day we need only adopt Prof. Forbes's own phraseology, and term his error a "fallacy."

In considering the effect upon the body of possible differences between maximum and effective alternating currents, we must take into account potential counteracting effects of increased rates of alternation. Our experience, so far, is that the slower the rate of alternation the greater the discomfort for the same current strength. Our paper dealt with a higher rate of alternation than that commonly in use in light circuits. It is therefore highly probable that the increased discomfort which would be produced by the slower alternations of a dynamo circuit would more than counterbalance the possible difference between effective and maximum current due to the use of an induction coil of much more rapid alternation.

Electricians generally show too marked a tendency to look upon the human body as an inanimate conductor, and apply to it the same laws. I need hardly reiterate what Dr. Harries insisted upon in his reply at the meeting, that the physiological conditions controlling the resistance of the skin make all the difference in the results of contact.

Our paper deals exclusively (as we mentioned therein) with phenomena *after contact*, and deliberately excludes from consideration factors involved in bringing about that contact.

We desire to emphasise the difference between *resistance* and *sensation*, and trust that in future this important point will not be lost sight of.

As indicated at the meeting, we have further investigations in progress, and therefore forbear entering now more fully into the points raised.

H. Newman Lawrence.

[We shall look forward with much interest to the further experiments of Mr. Newman Lawrence and his colleague; as it is, their paper must prove of much service, and should tend to render engineers of the reckless nature of "our only electrician" more than ever cautious in the handling of alternating current plant.—EDS. ELEC. REV.]

Far Distance Dynamo.

The arrangement described in your correspondent's letter in your issue of the 28th ultimo refers to the so-called manner of "over-compounding" a dynamo. Such over-compounding can only produce the same effect as the F.D. when the over-compounded E.M.F. is under about 20 per cent. of the normal voltage, say 110 volts, and when the chief dynamo is used only for a single main circuit.

In all other cases the over-compounded dynamo will be of no advantage, *i.e.*, the regulation for the constant lamp potential is non-automatic, but must be effected either by hand or by means of automatic resistance, &c.

As to the F.D., the losses of the potential in the feeders may be taken as 15, 20, 30 and even more volts, as required in the case in question, in accordance with Thomson's law of economy the F.D. will then always maintain a constant potential at the lamps, say 110 volts, in the most exact and automatic manner, whilst the chief dynamo "G" always gives the same E.M.F. 110 volts at its own terminals. In this way it is possible to light lamps directly from these terminals, without feeders, and to use the same 110-volt lamps throughout the installation. This will be the case when from a *single* main station lamps are to be burnt, not only in the neighbourhood of the chief dynamo "G," but also at one of more distant places by long feeders F.F. where there is great loss of potential, see sketch 1.

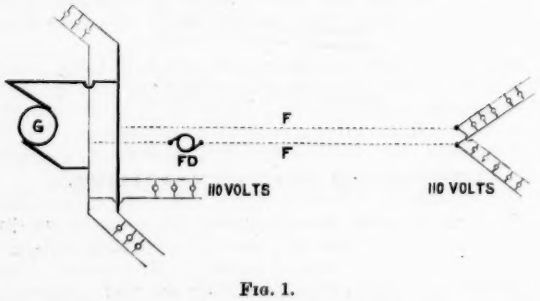


FIG. 1.

In central stations for thousands of lamps several feeders, F.F., of course, will be necessary, and in every such feeder the loss of potential will be equalised by means of a F.D. in the way described. The advantage derived hereby is that the sectional area of each feeder requires only to be taken in accordance with Thomson's law of economy, *i.e.*, by allowing in long feeders a greater loss of potential than in shorter ones, so that there will be a great saving in copper. The F.Ds. maintain at the several points, 1, 2 and 3, as shown in the plan annexed, a constant potential, and, as we may repeat, in the most exact automatic and most economical manner, without any loss by means of regulator resistances, there being required in no way whatever any electrical regulation in the station, the attendance being reduced to minimum, which is confined only to oiling the bearings of the machines, &c. The following sketch shows such a general scheme. Also here lamps burn directly from the terminals of the chief dynamo "G" with the same constant voltage as the distant lamps anywhere in the far lighting district.

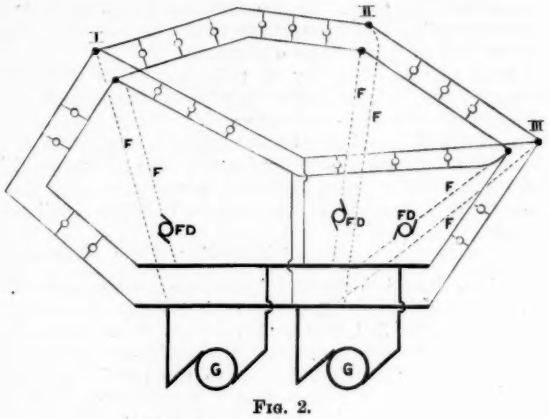


FIG. 2.

As to the cost price of the F.D. and the chief dynamo in this arrangement, it must be borne in mind that the watts of the F.D. are produced independently of the chief dynamo. In our case the chief dynamo gives only the actual watts required in the lamps, and not the loss in the feeders, therefore ordinarily without an F.D. there would be required a comparatively larger chief dynamo.

Bolling and Lowe.

April 2nd, 1890.

Alternating Current Motors.

Number 643 of your esteemed journal contained some remarks of Dr. Nordmann on the Report of the Frankfort Commission, which need the following rectification:—

The calculation relative to the capacity of the larger alternate current motor, made out by Dr. Nordmann to show a capacity of 42 H.P. is erroneous. Supposing an efficiency of 87 per cent.:—Dr. Nordmann states that the 25 H.P. alternate current motor, the same machine which appears as a generator for 30,000 watts, requires 47 H.P. to drive it when used for this latter purpose. This is correct; but his further calculation, resulting in a capacity of 42 H.P. for the motor used as such, is incorrect.

The re-calculation gives, in fact, the following results:—

It is true that the aforesaid machine, as a generator, is stated to give 15 ampères at 2,000 volts as a maximum. The charge, then, is limited by a current of 15 ampères. But, when working as an electro-motor, the machine is supplied with a tension of 1,800 volts, that is, with 27,000 volt-ampères.

It is well known that by the displacement of phases there exists a difference between the apparent volt ampères and the effective energy expressed in watts, and, in the case in view, this energy represents only 90 per cent., or thereabouts, of the multiple of volts and ampères, viz., $27{,}000 \times 0{\cdot}90 = 24{,}300$: and this with an efficiency of 87 per cent.

$$\frac{24{,}300}{736} \times 0{\cdot}87 = 28{\cdot}71 \text{ H.P. effective.}$$

Besides, the diagram of the efficiencies of the motor referred to, shows at first sight that its normal output is, in fact, about 25 H.P.

The final conclusions drawn by Dr. Nordmann from his erroneous calculations are, therefore, equally groundless.

M. Deri.

Vienna, *April 2nd*, 1890.